

# **Advances in the Modular Multiscale Microphyscs and Transport Package for Alaro-0**

Luc Gerard

8 April 2008



# Advances in 3MT

1. General comments
2. The updraught in 3MT
3. Updraught closure in 3MT
4. Cascade and closure
5. Entraining ascent segment
6. Detrainment area
7. Convective fractions
8. Numerical consistency
9. Recent results : Heavy thunderstorms — Downpours — Thin squall lines
10. Further work

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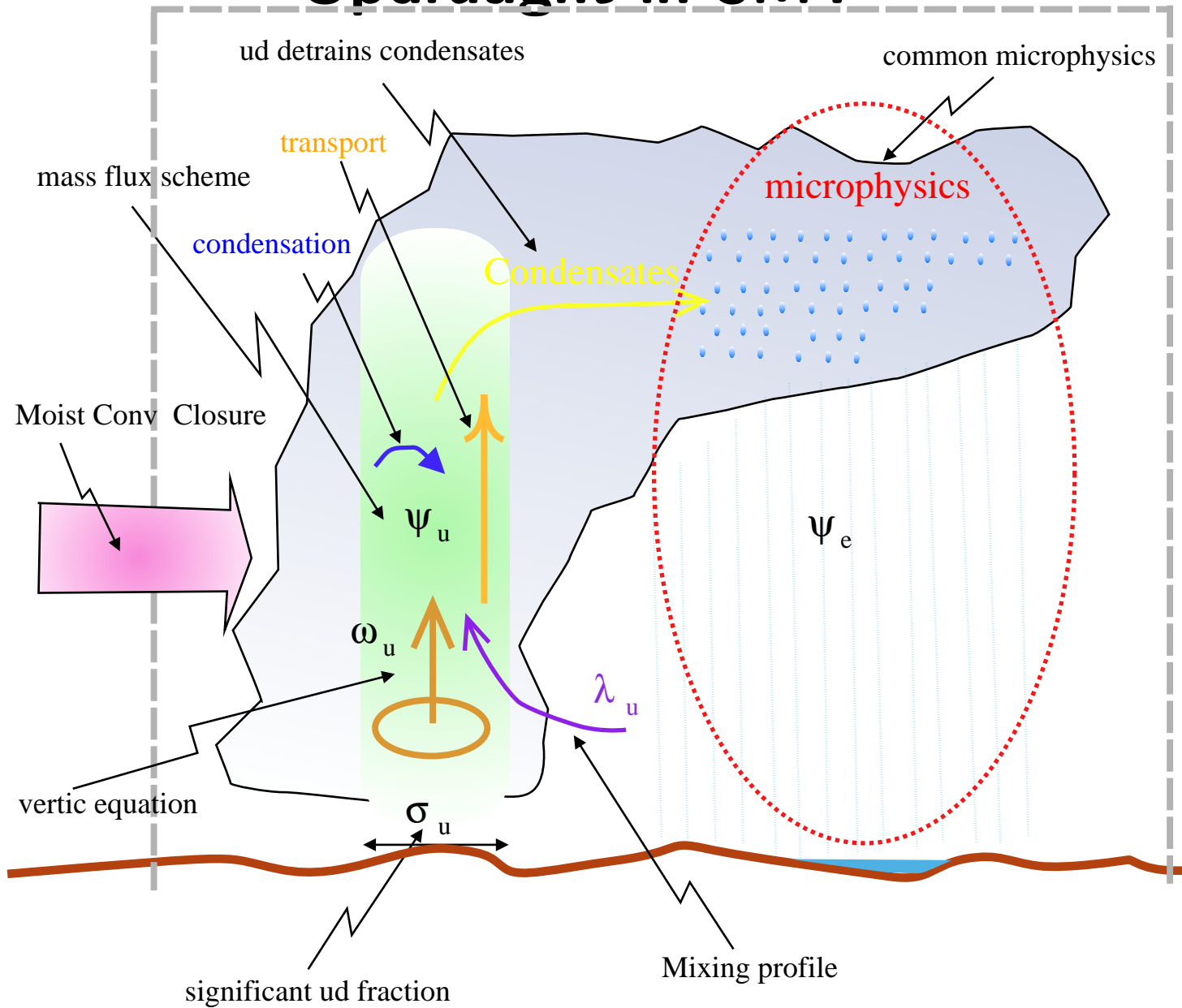
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convective ≠ stratiform



# Updraught in 3MT



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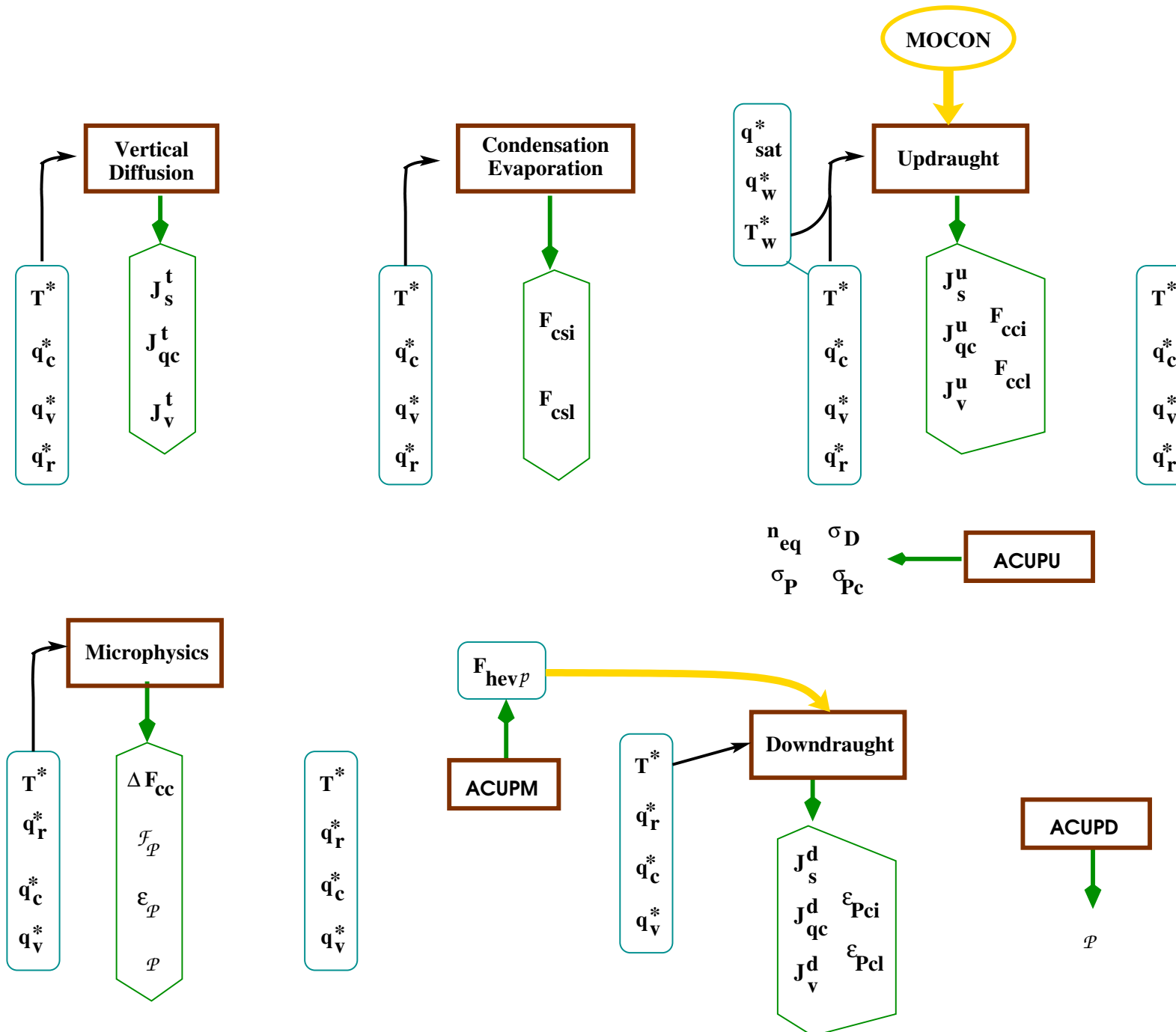
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...while local turbulent diffusion acts on buoyancy profile!

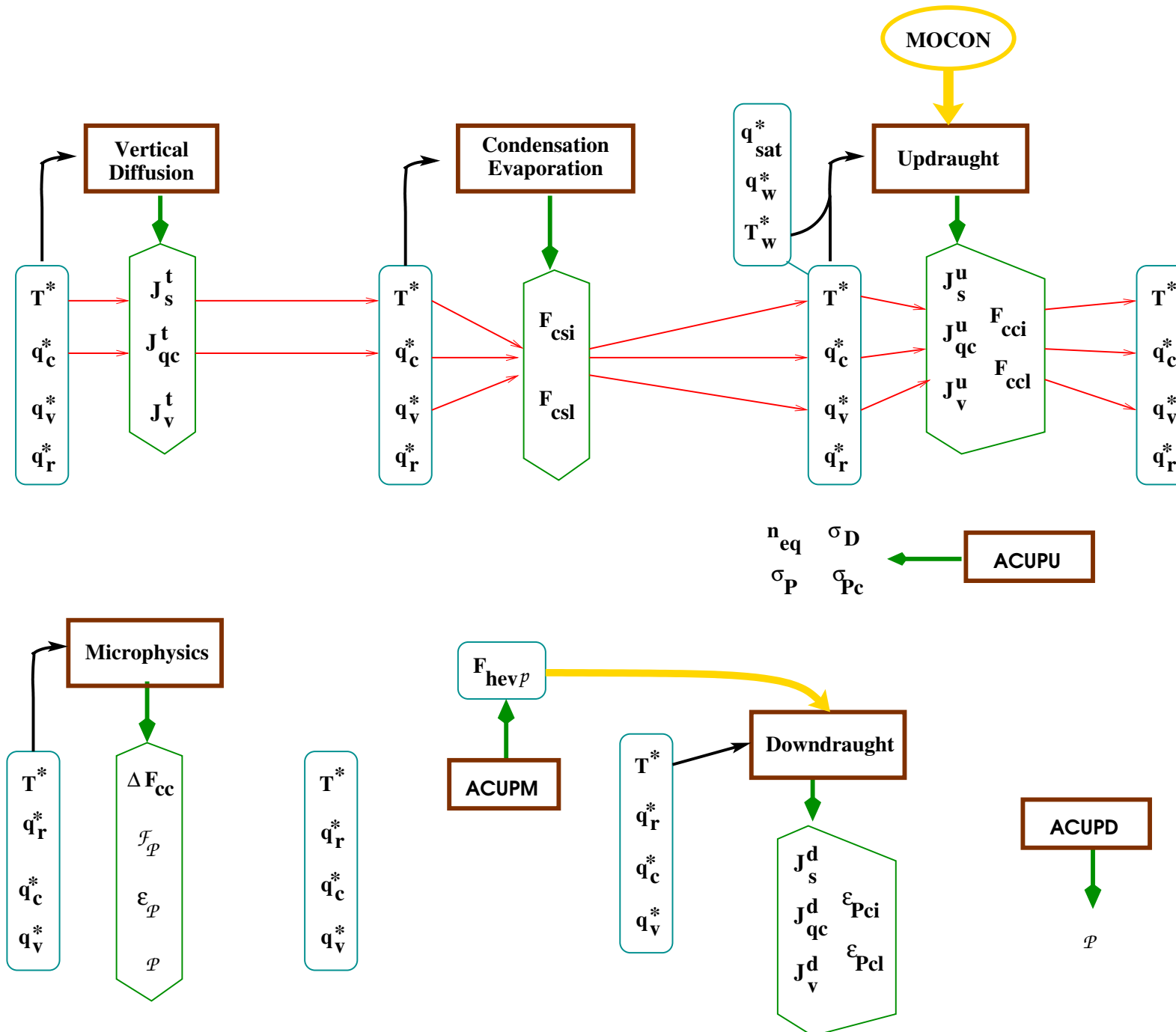


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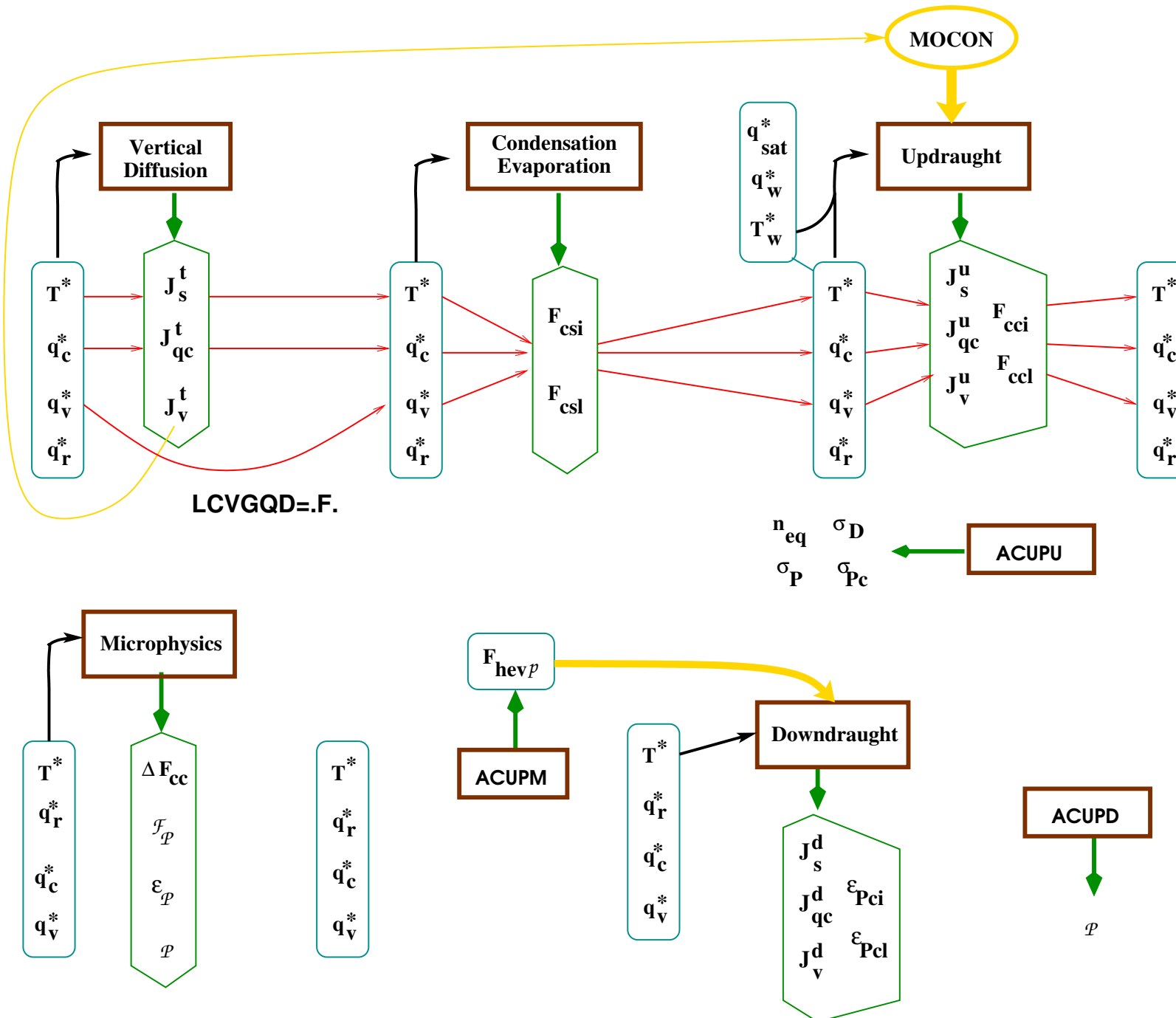
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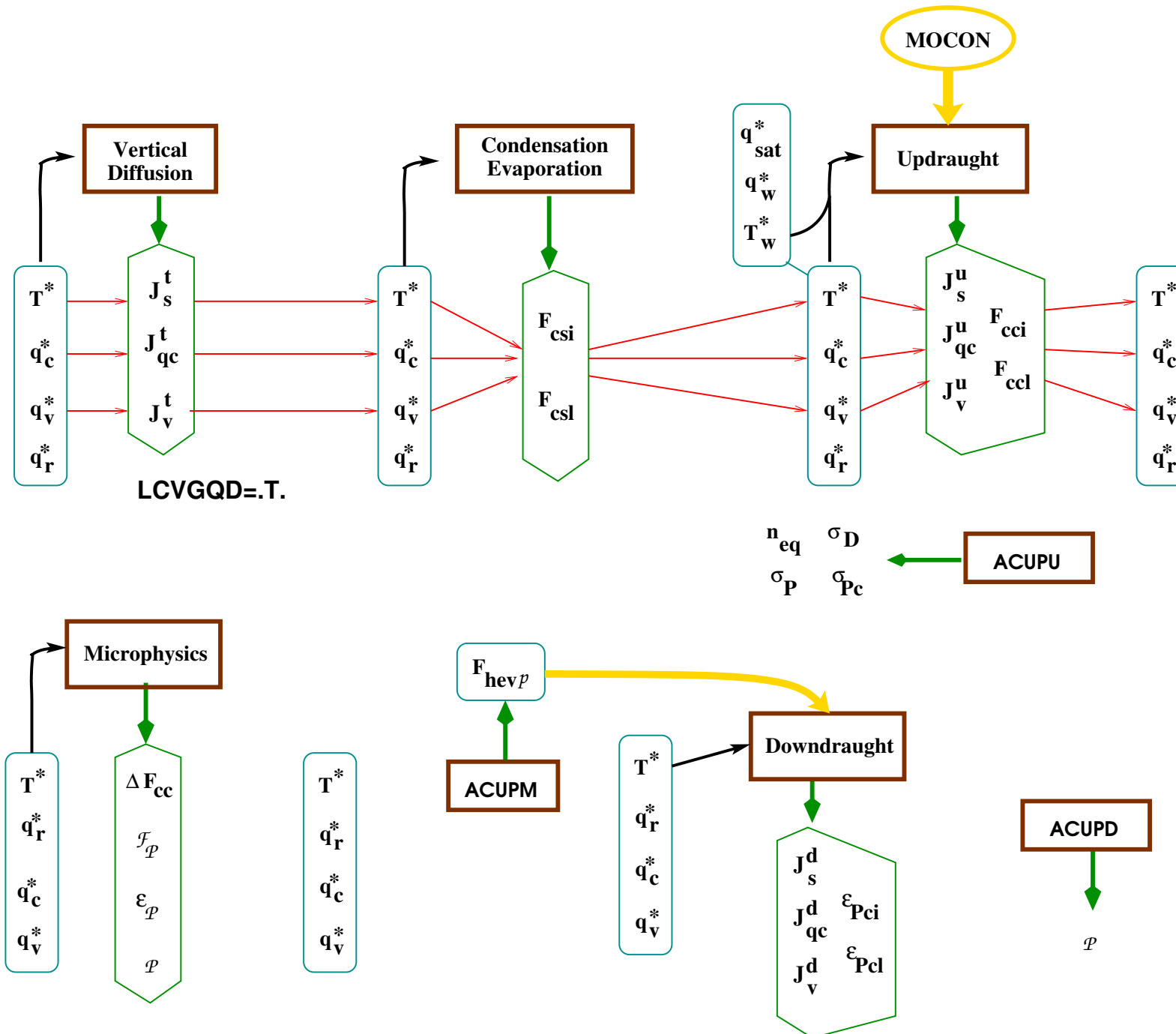
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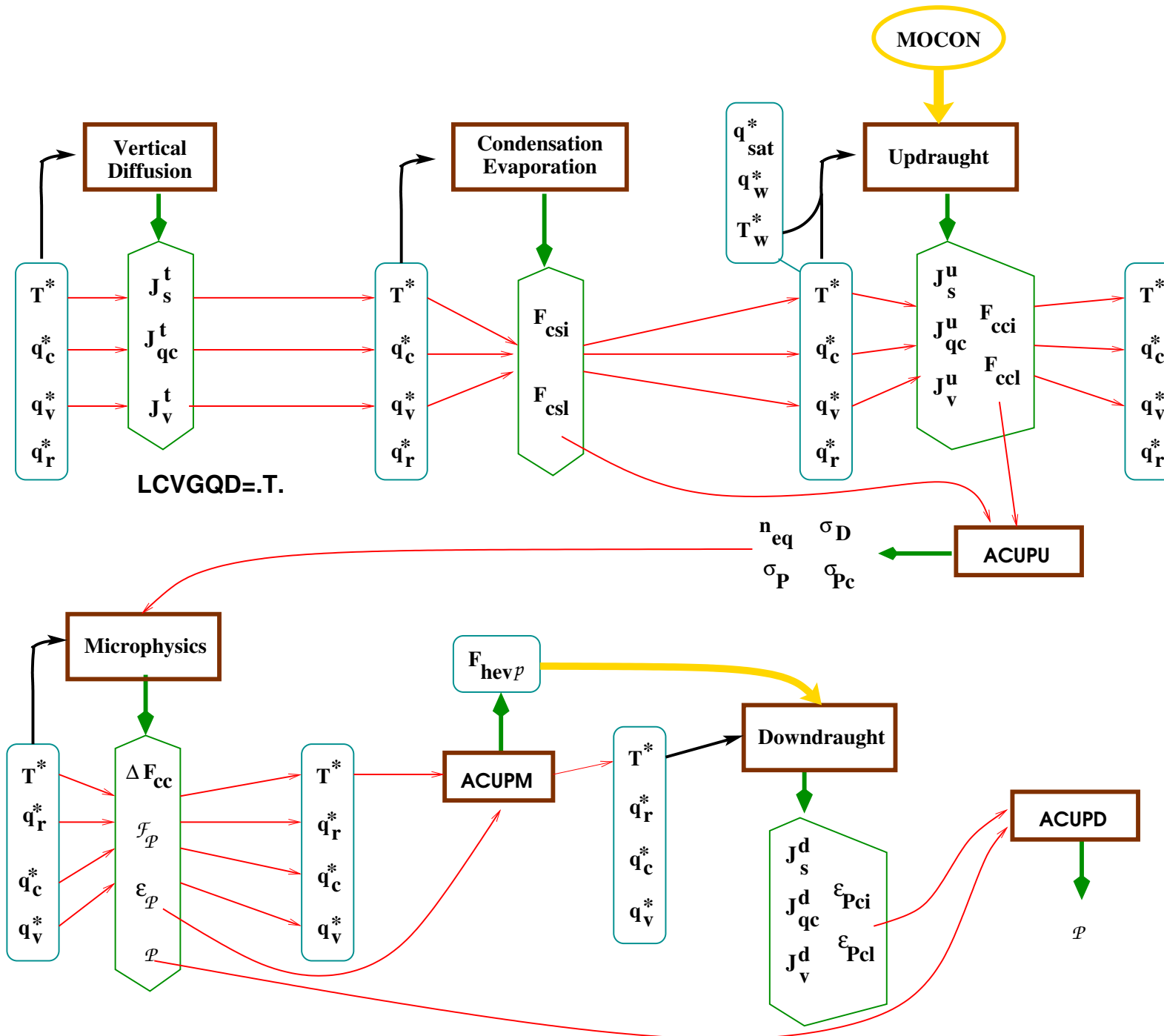
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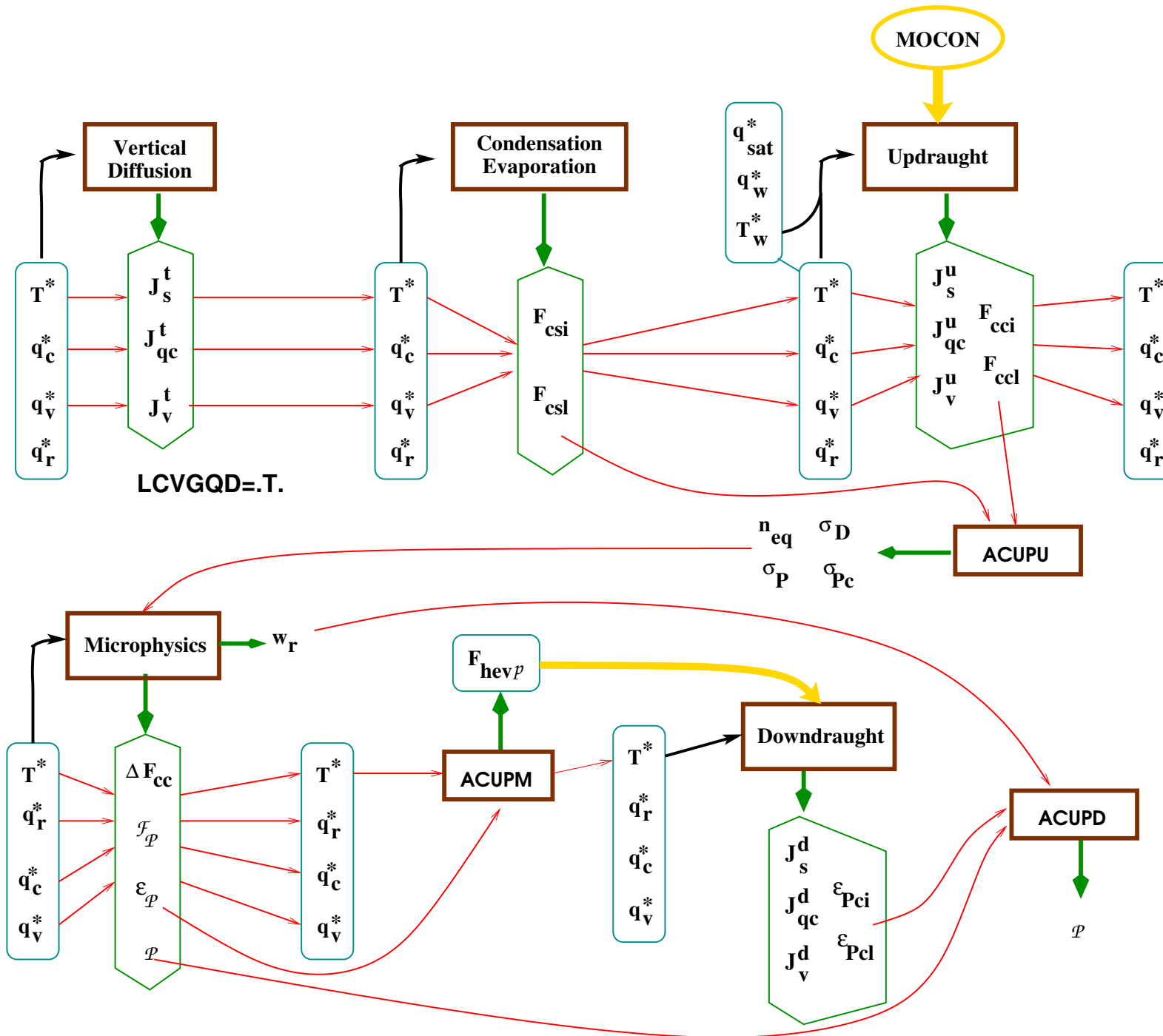
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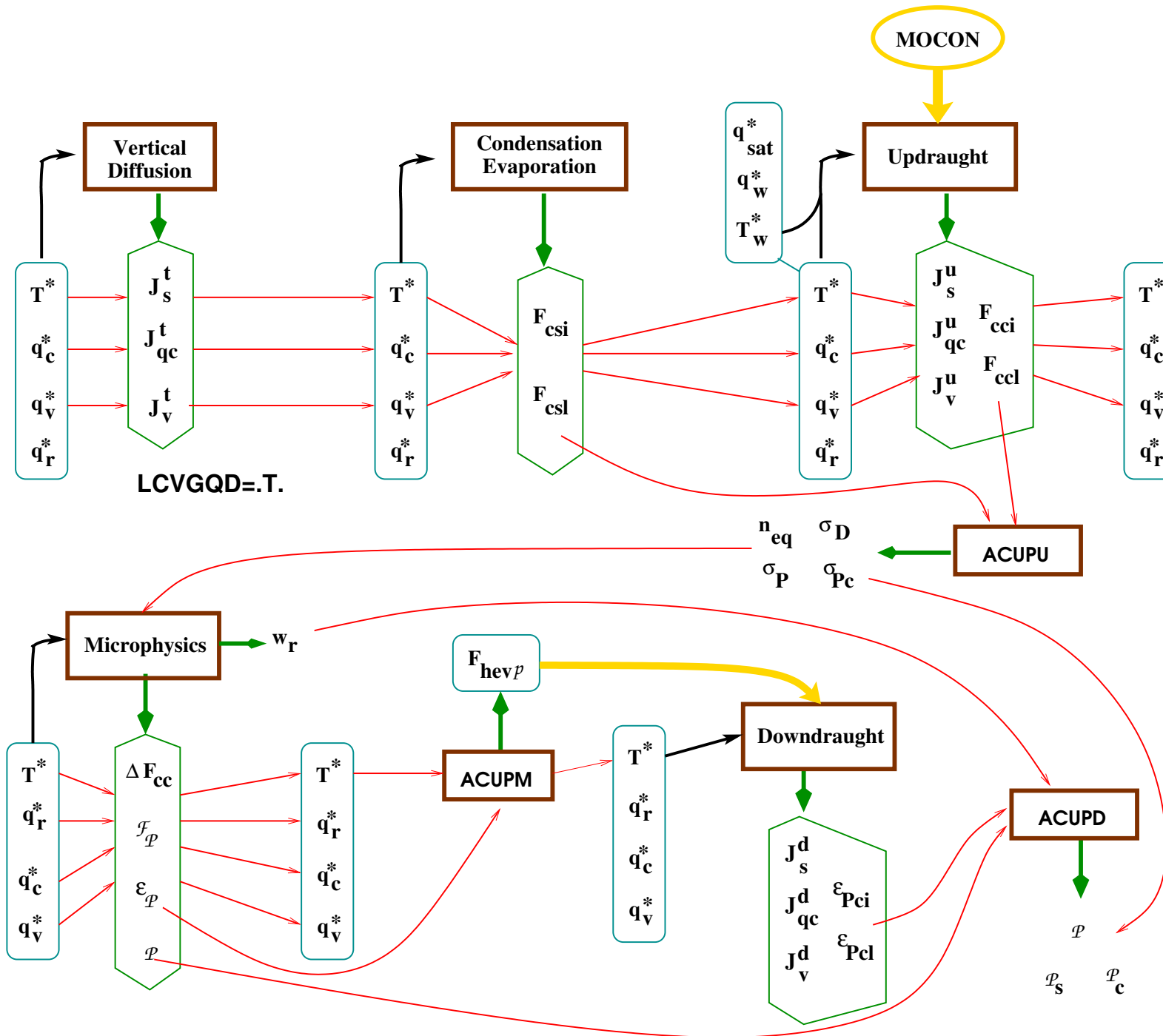
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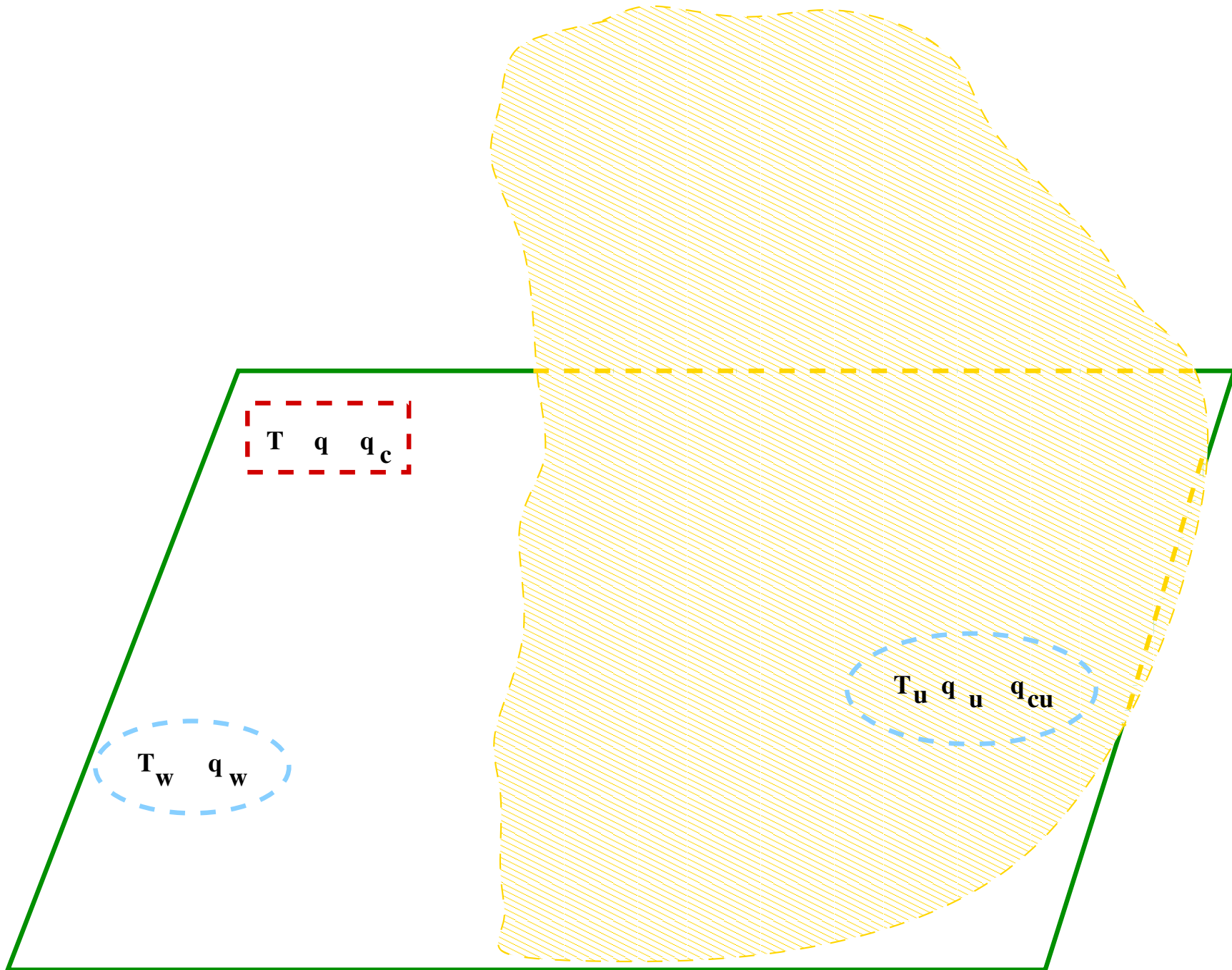
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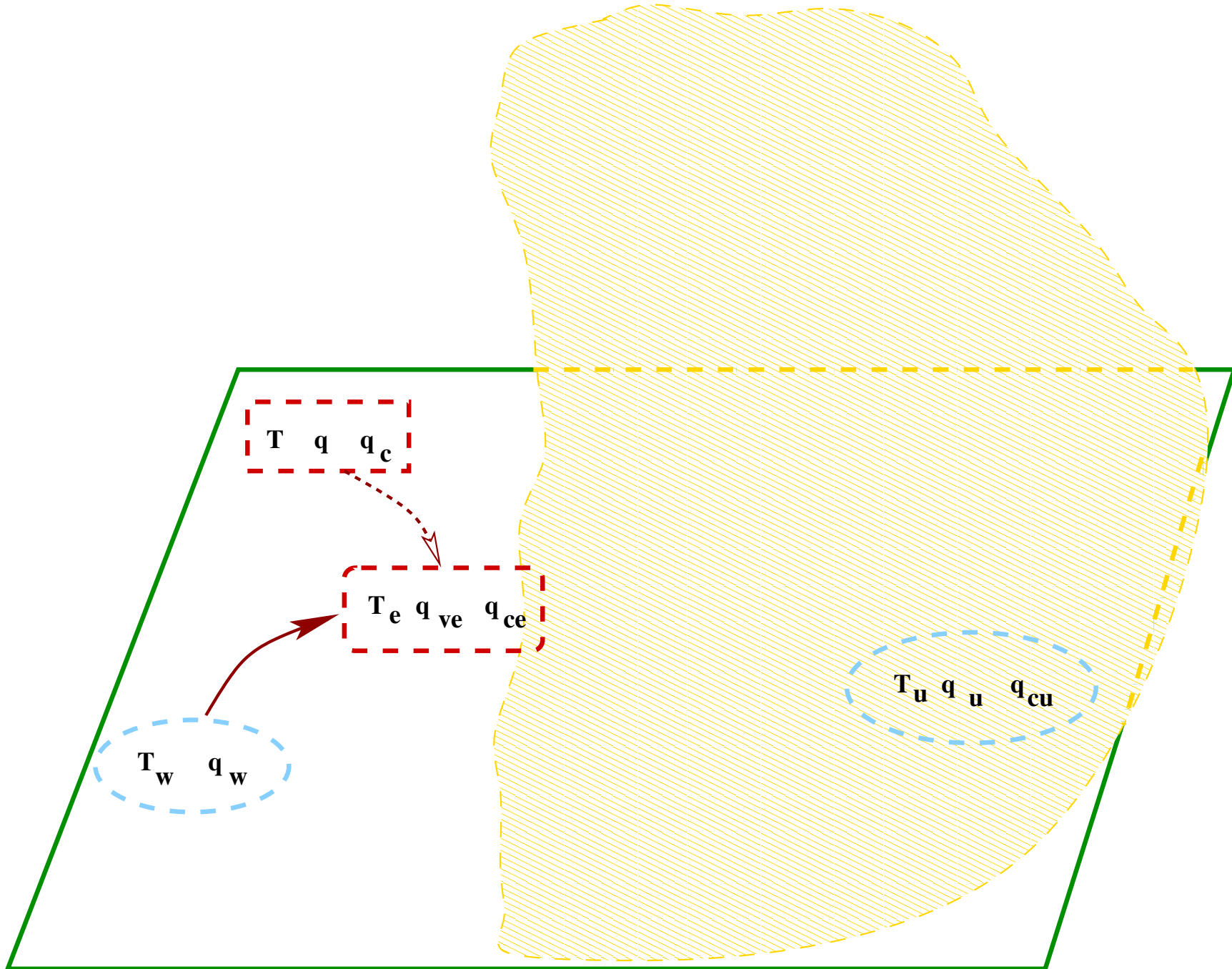


# Entraining ascent segment

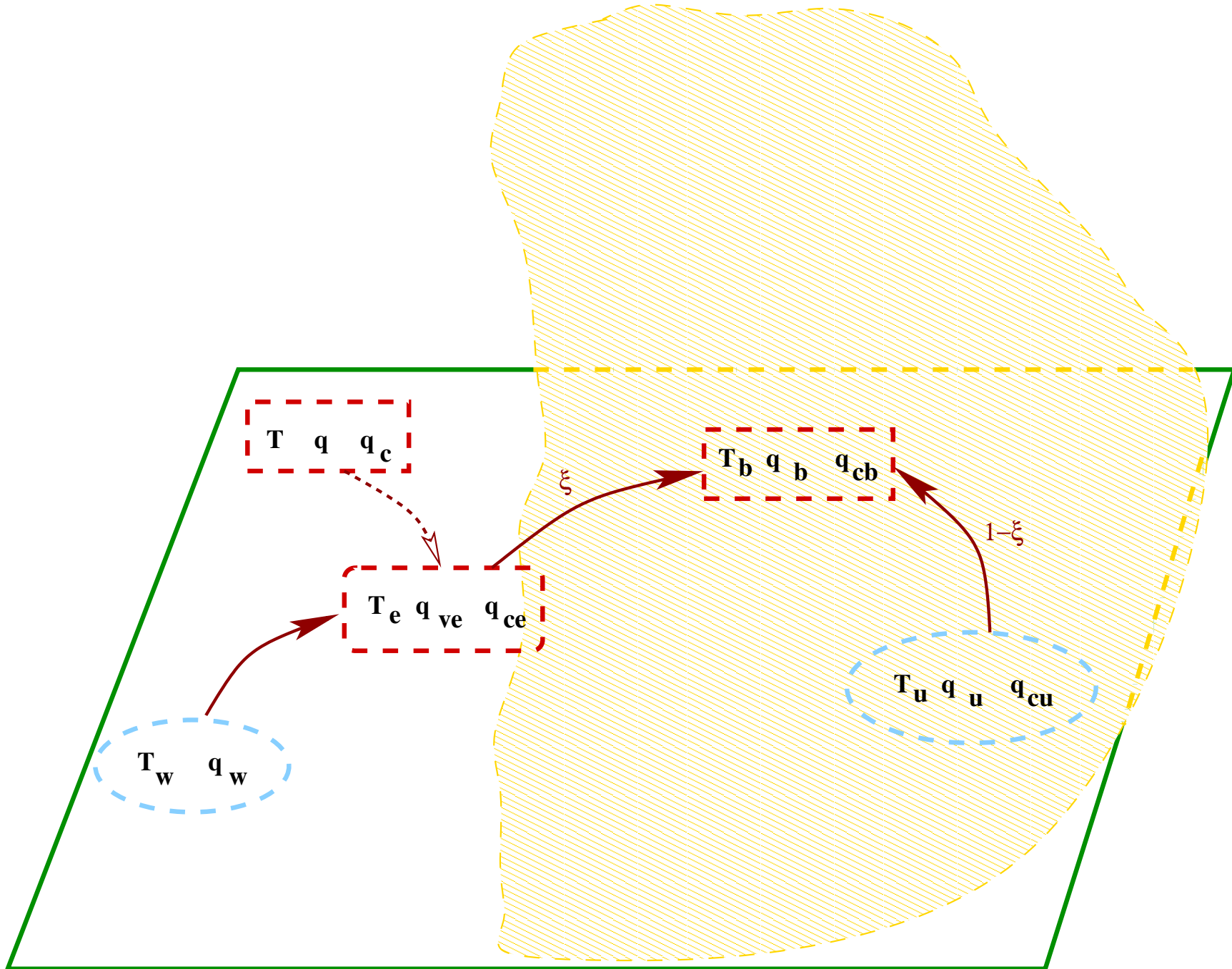
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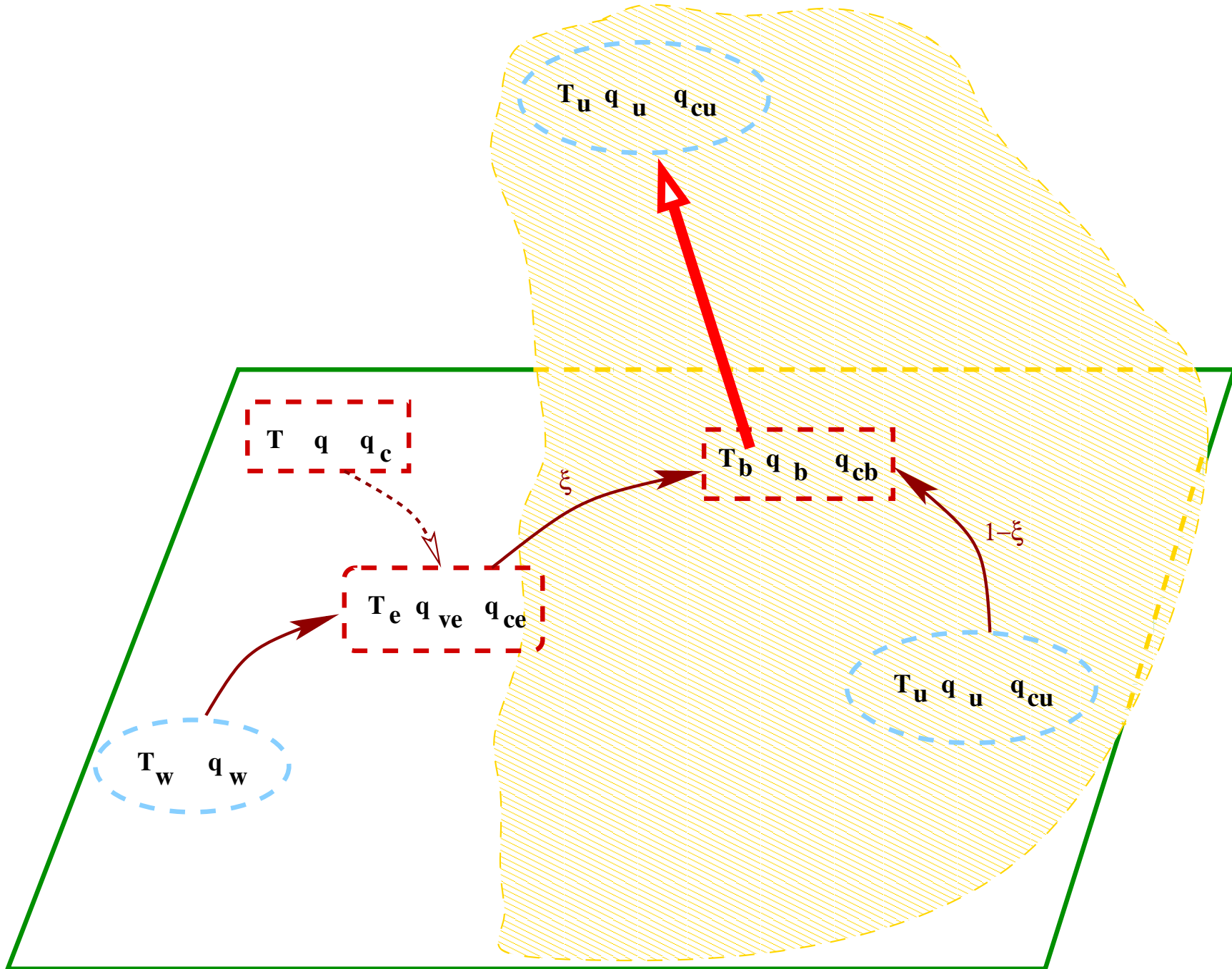
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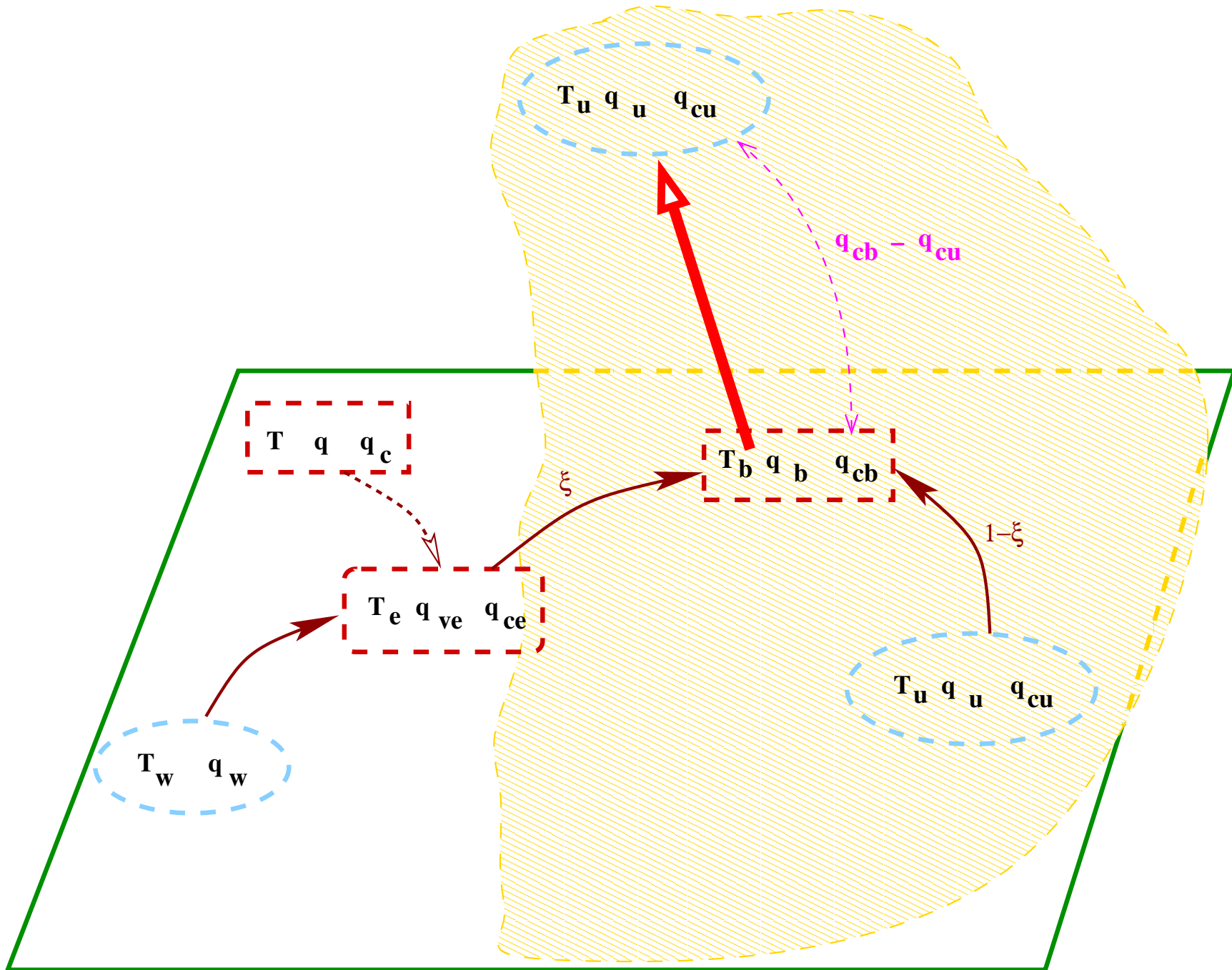
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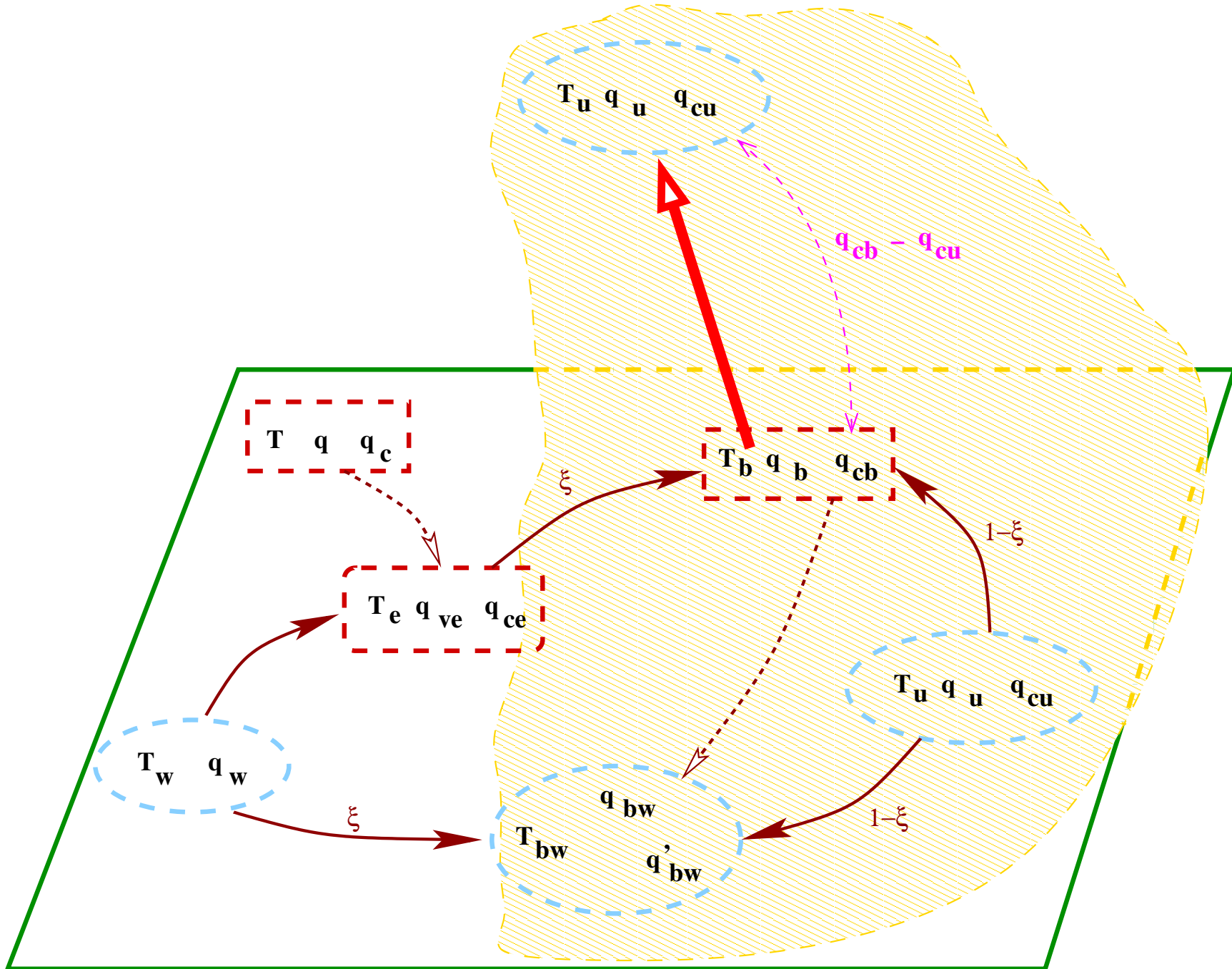
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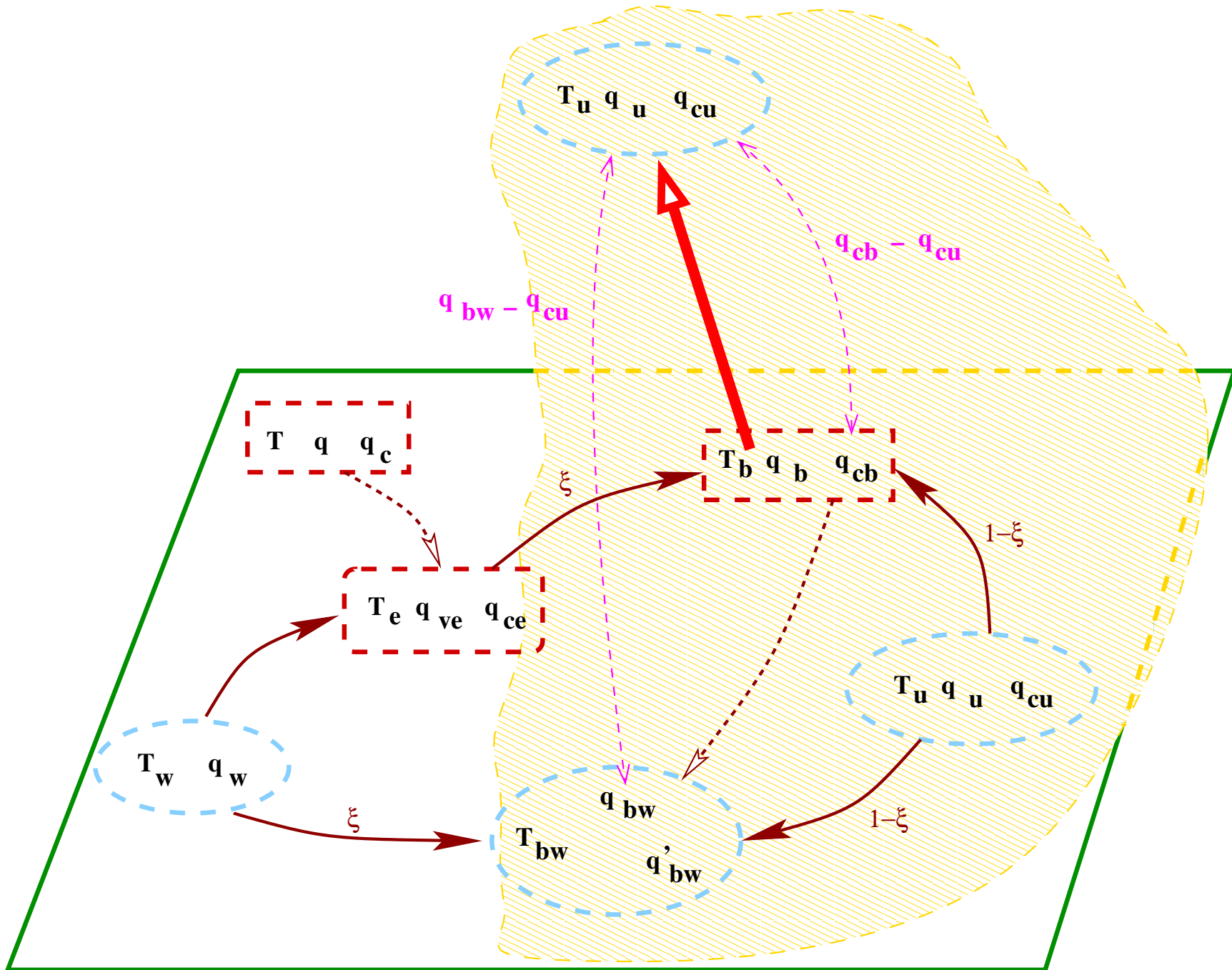
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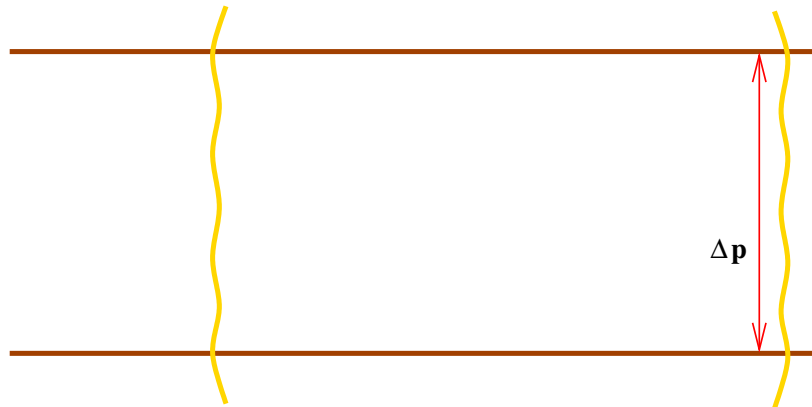
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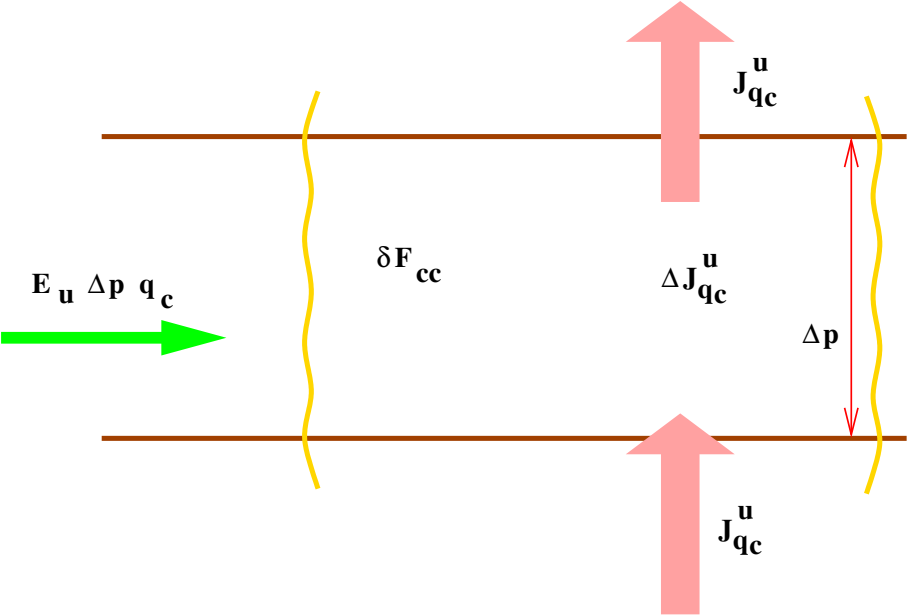
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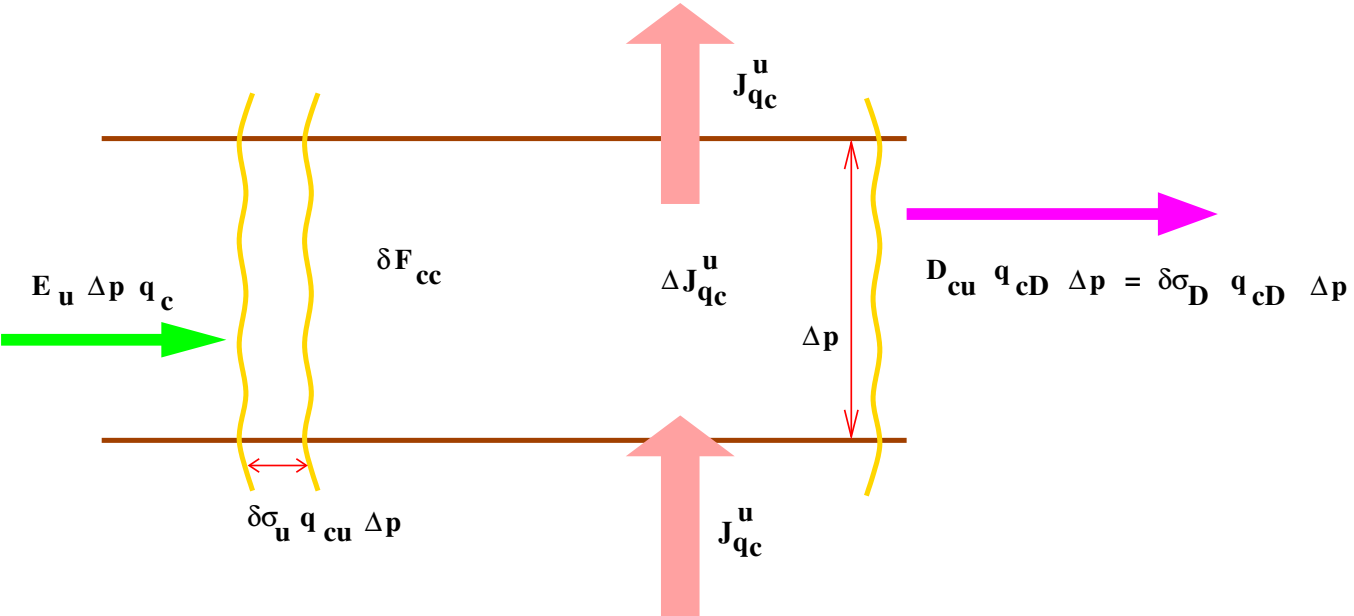
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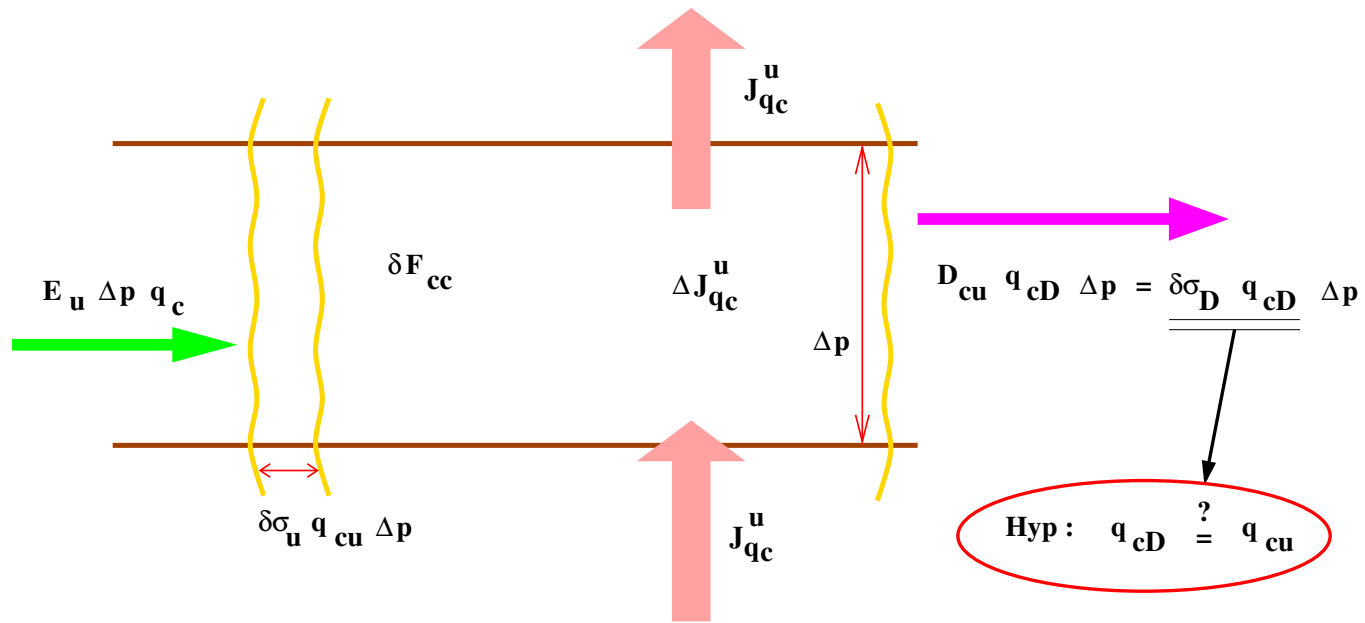
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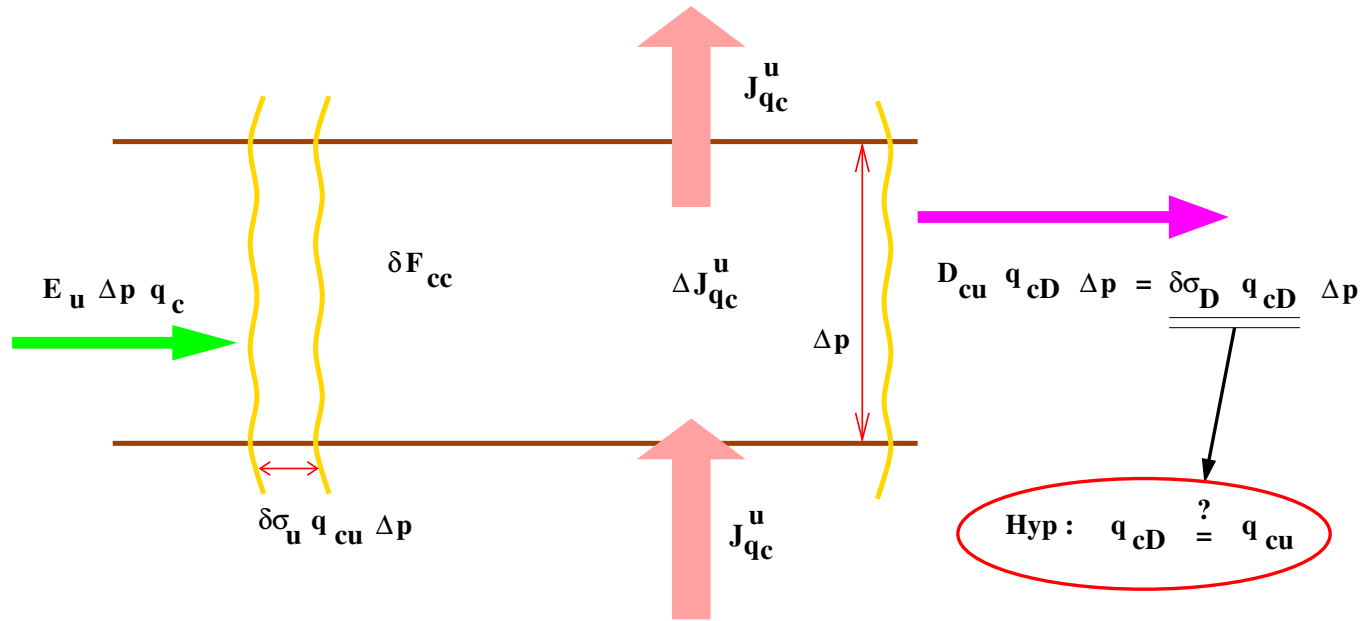
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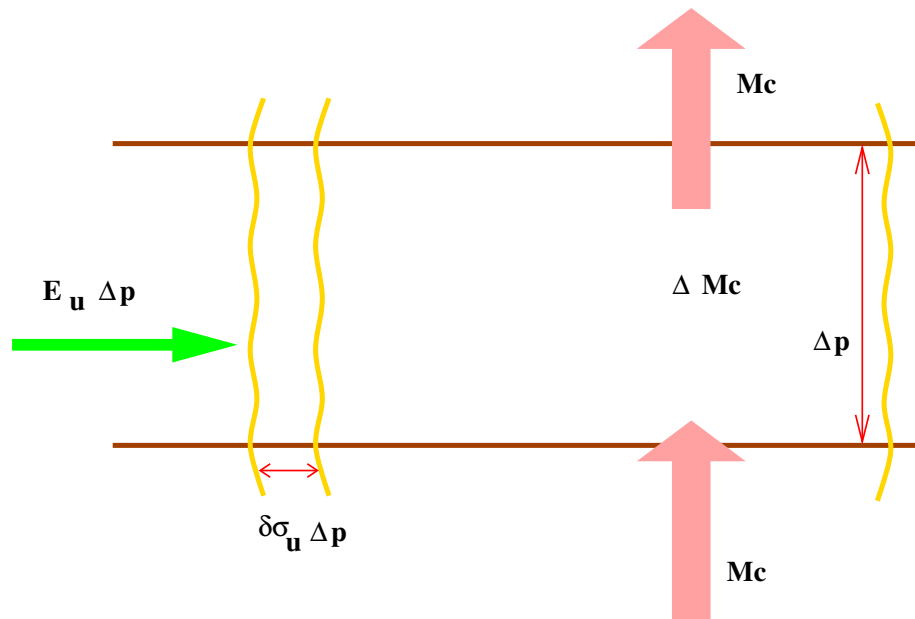
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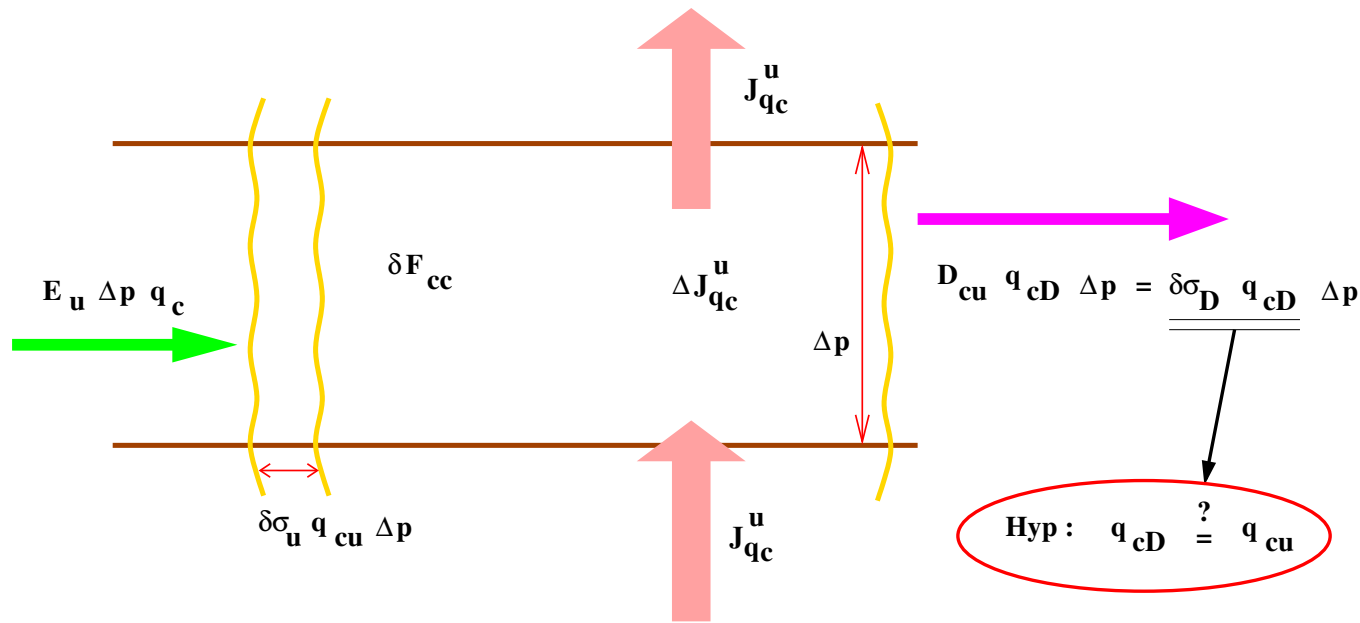
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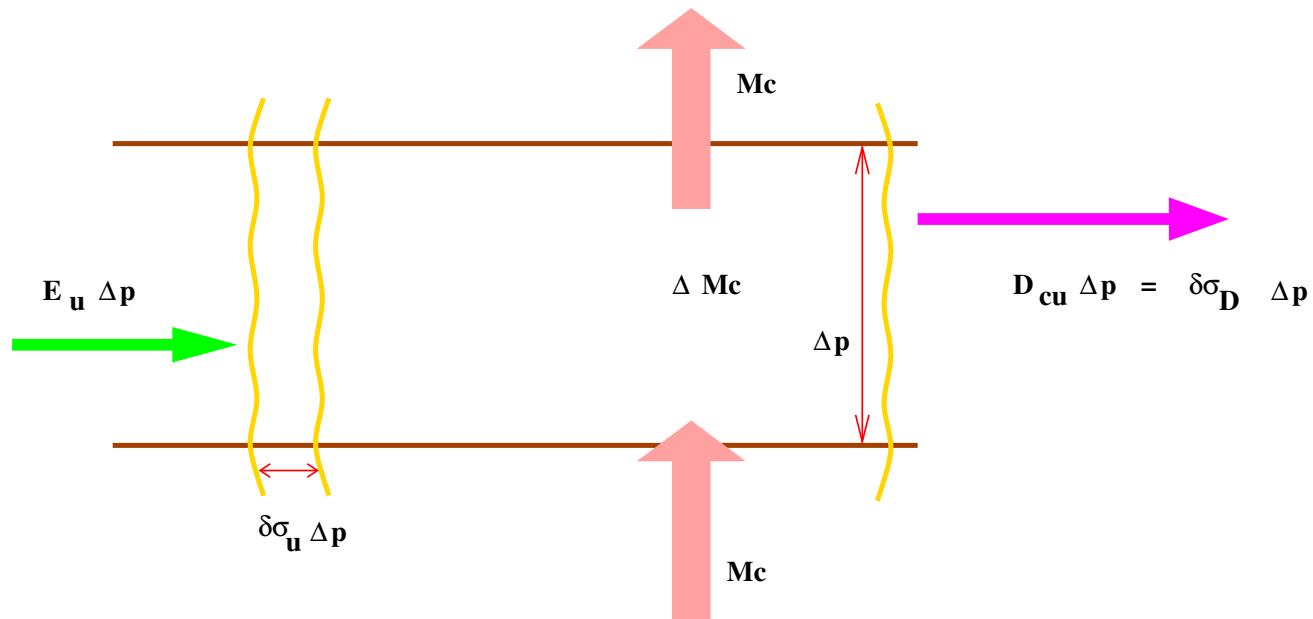
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# Relation to convective fractions

$\sigma_D \neq \delta\sigma_D \Rightarrow$ accumulation

$$\sigma_D^+ = \min(1 - \sigma_u^+, \sigma_D^- \cdot e^{-\frac{\Delta t}{\tau}} + \delta\sigma_D)$$

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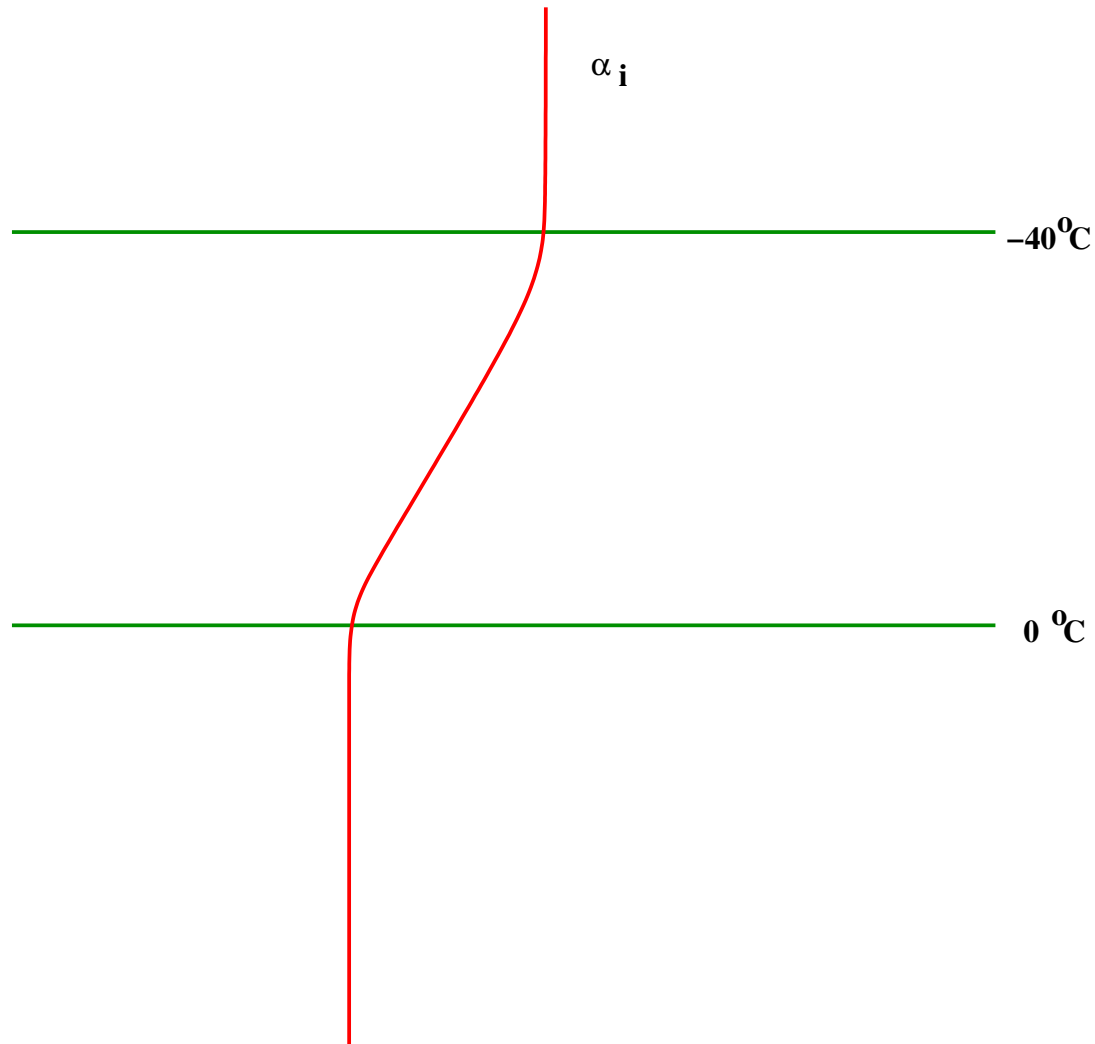
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... $\sigma_{\text{prot}}$  significantly larger than  $\sigma_{\mathcal{P}_c}$  (e.g. 3 times)

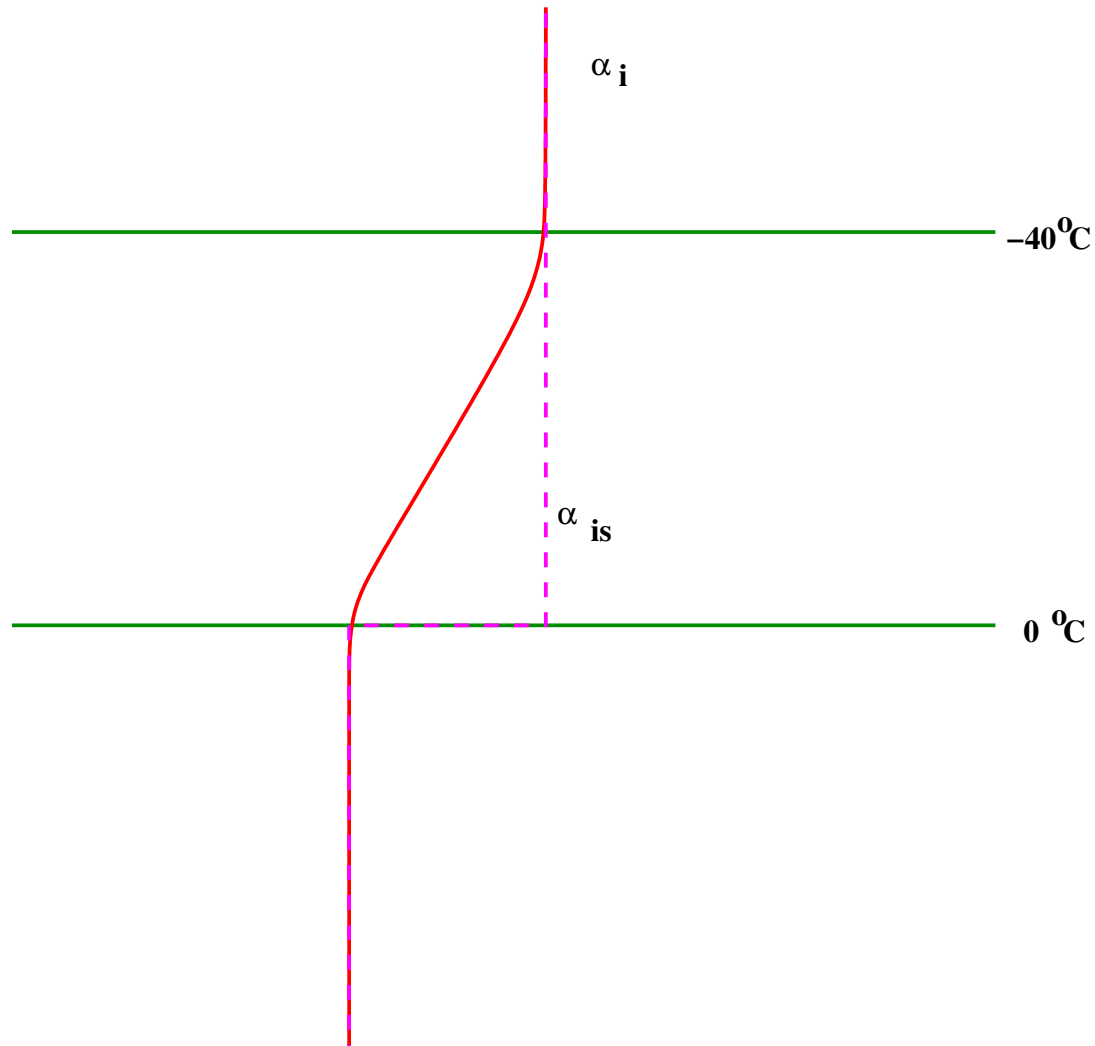
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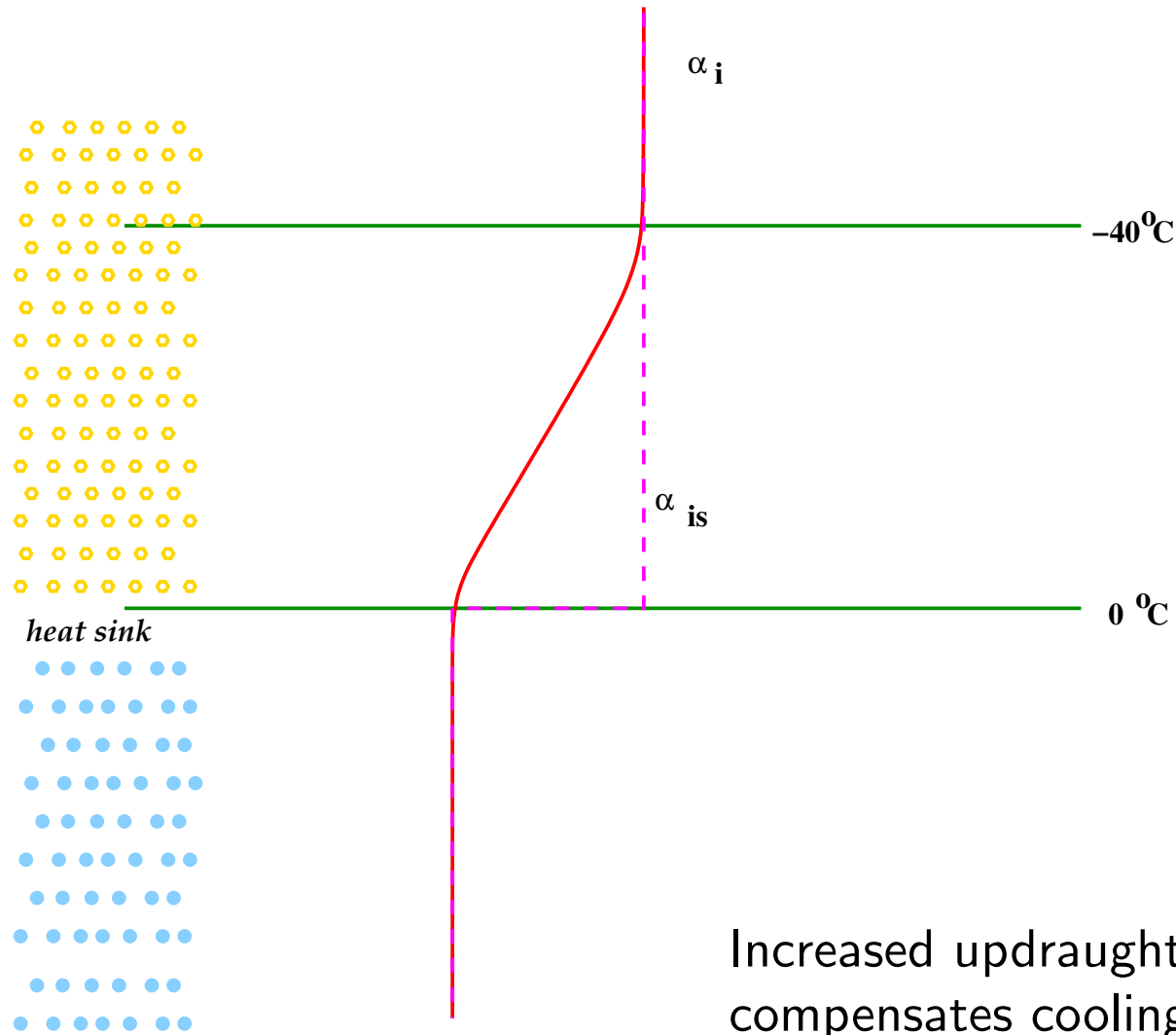
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Use instead  $\alpha_{is}$  step profile  
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Increased updraught condensation warming  
compensates cooling by heat sink  
preventing loss of buoyancy at further time steps

# Numerical consistency

Transport :

$$J_{\psi}^u = \frac{1}{g} M_c (\bar{\psi} - \psi_u) \qquad \frac{\partial \bar{\psi}}{\partial t} = -g \frac{\partial J_{\psi}^u}{\partial p}$$

$\implies$  Implicit discretisation to compute  $J_{\psi}^u$  from  $M_c$ ,  $\Delta \psi_u$  and  $\Delta \bar{\psi}$ .



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Condensation :

$$\frac{\partial \bar{\psi}}{\partial t} = -g \frac{\partial F_{cc}}{\partial p}$$

where local condensation is proportional to  $M_c$

$\implies$  use same discretisation as transport.

# Recent results

Computational load , 46 levels, 24h run including DFI and complete I/O

Model configuration	nb points	$\Delta t$	Memory	Exec. Time
Operational Aladin Belgium 7km	240x240	600s	100	100
idem + Lopez Microphysics	240x240	600s	144	117
Alaro-0 wo 3MT, 7km	240x240	600s	155	165
ALARO-0 7km	240x240	600s	192	185
ALARO-0 4km	400x400	180s	378	500
ALARO-0 4km small domain	180x160	180s	96	154
ALARO-0 2km small domain	320x200	100s	213	862
ALARO-0 NH 2km small domain	320x200	60s	243	1851

Rem : execution time depends on

- number of points, number of steps, number of model variables
- time spent in parametrisation following atmospheric situation
- initialisation steps
- i/o which increases when saving bigger files.

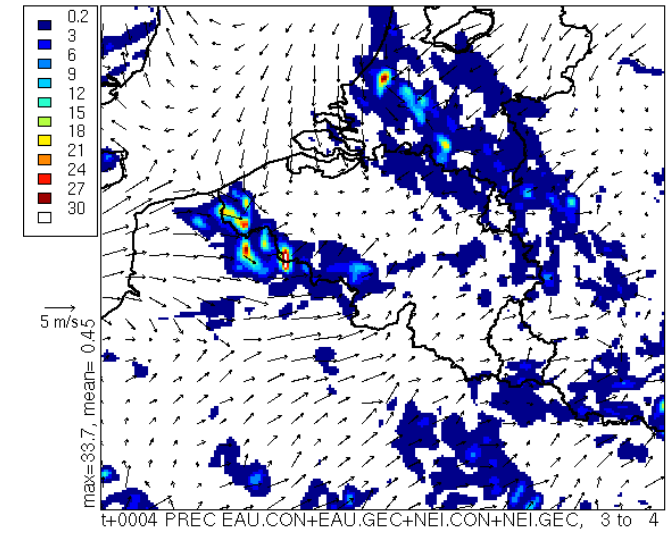
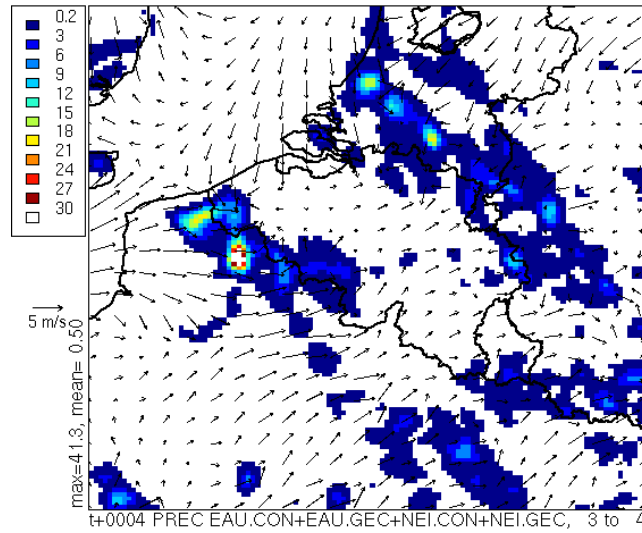
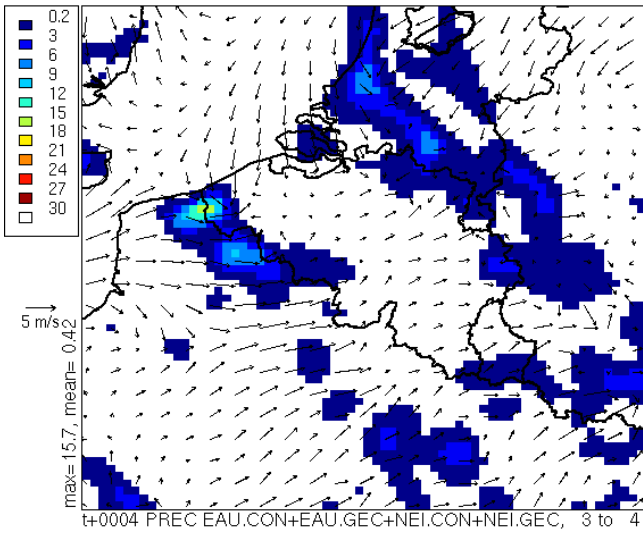
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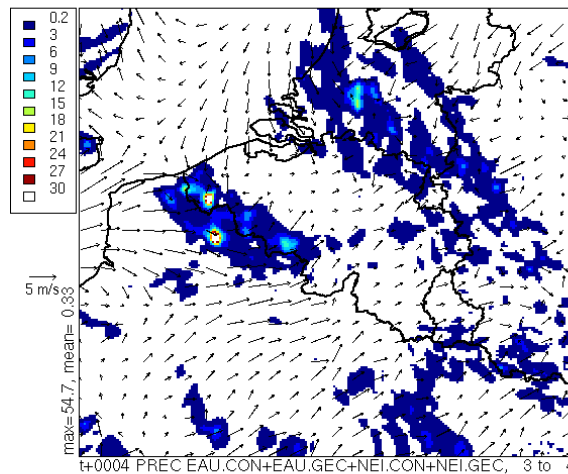
tA7vl : 2005/9/10 z12:0 +4h

tA4vl : 2005/9/10 z12:0 +4h

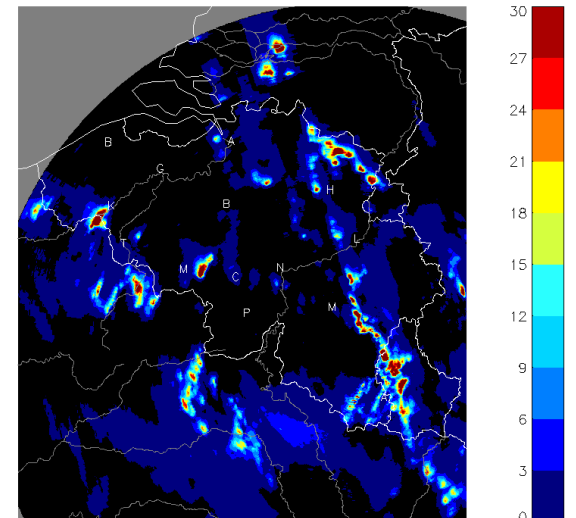
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tA2vl\_nh : 2005/9/10 z12:0 +4h



1h radar precipitation accumulation (mm) Starting at 10/09/2005 15 UT 12 /12 RMI - Belgium

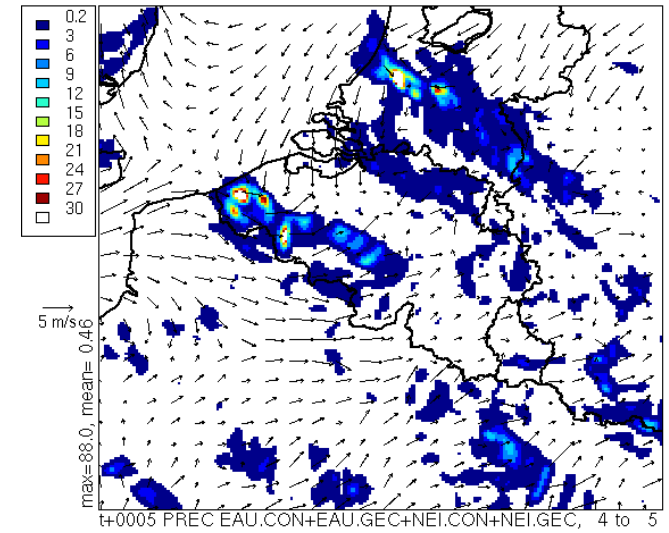
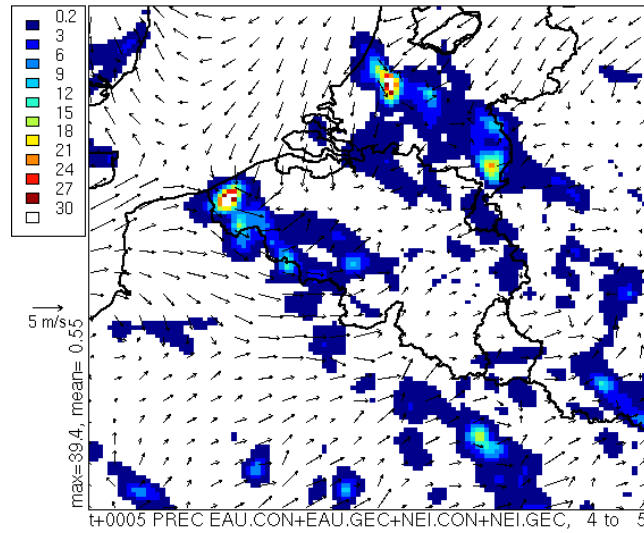
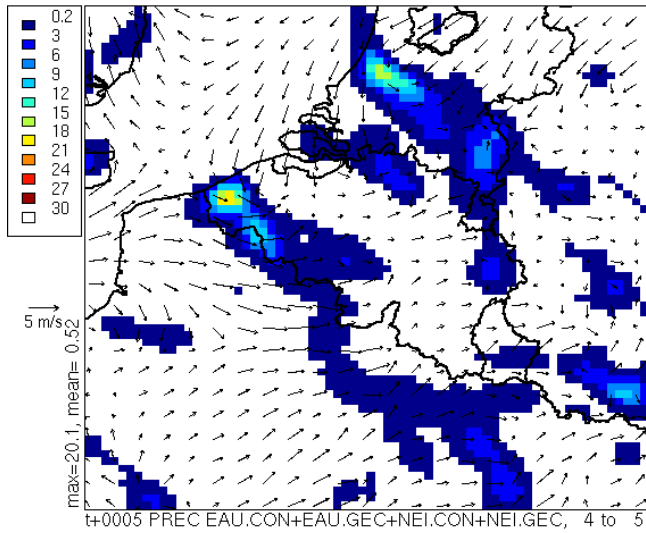


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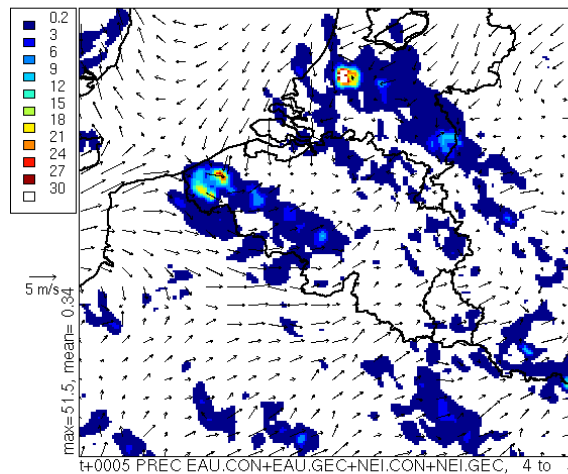
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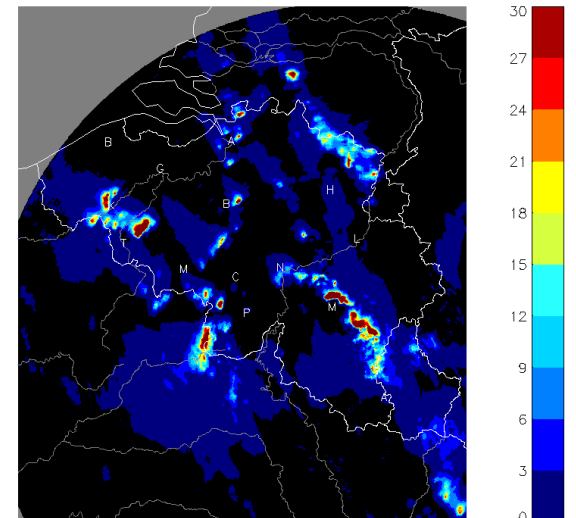
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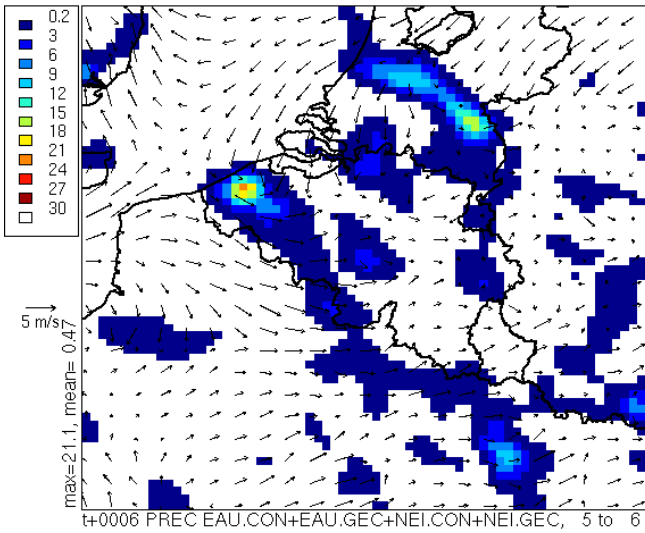


1h radar precipitation accumulation (mm) Starting at 10/09/2005 16 UT 12 /12 Radar Wideumont RMI - Belgium

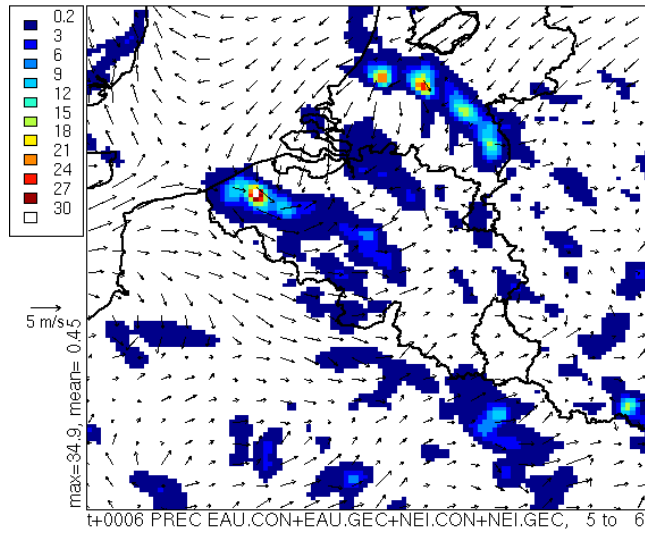


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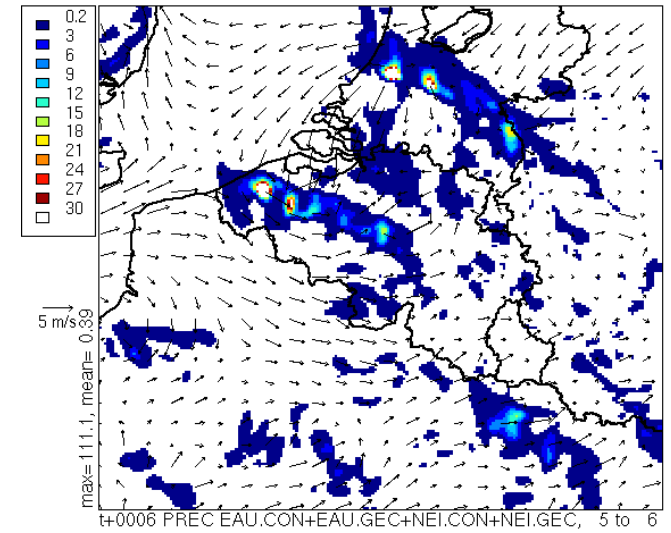
tA7vl : 2005/9/10 z12:0 +6h



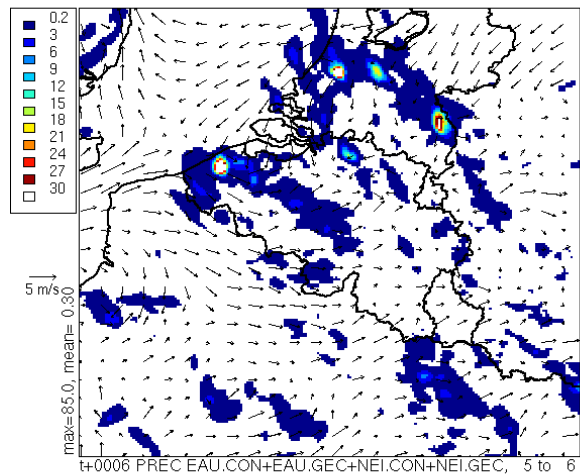
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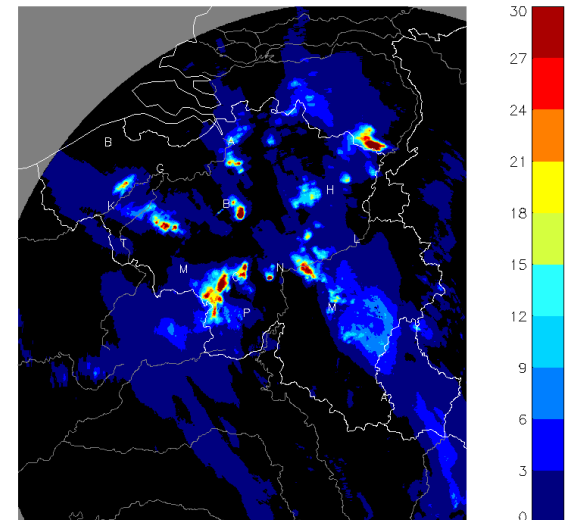
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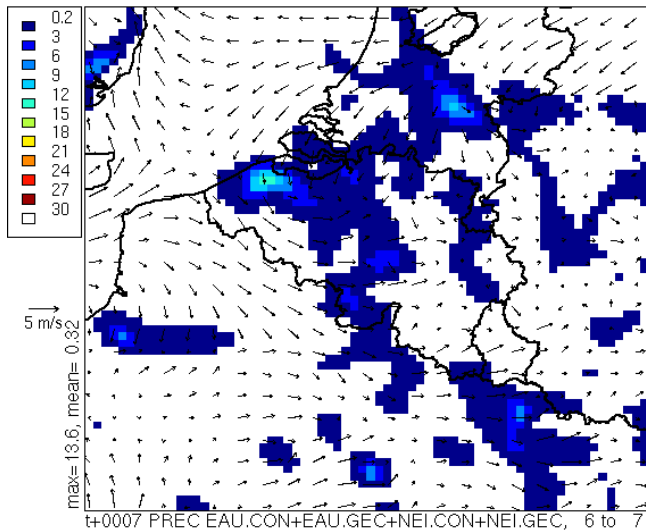


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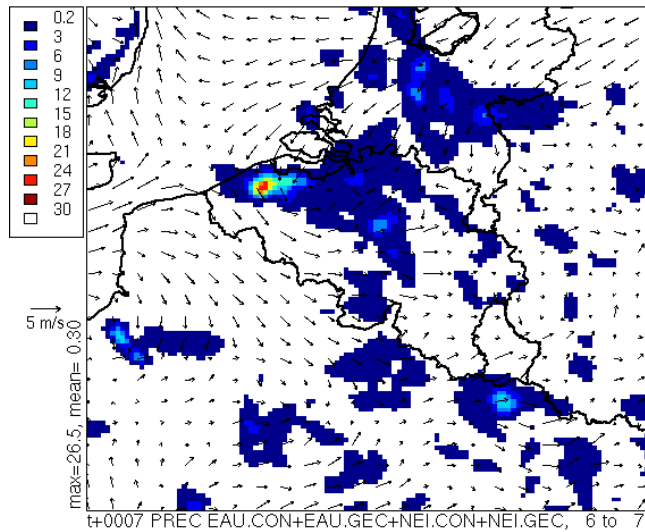


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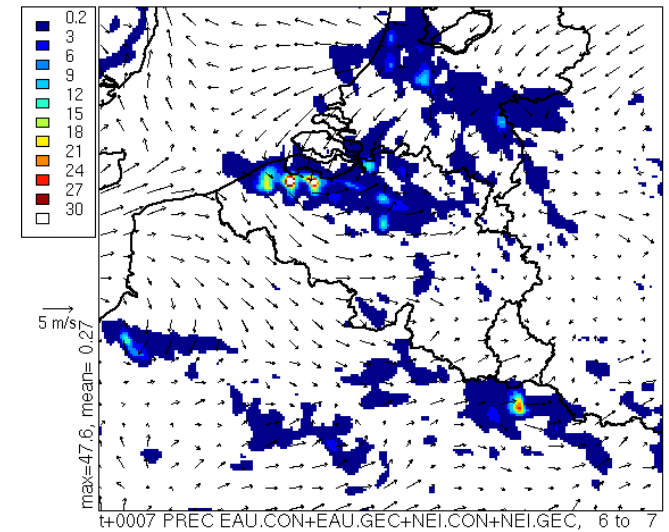
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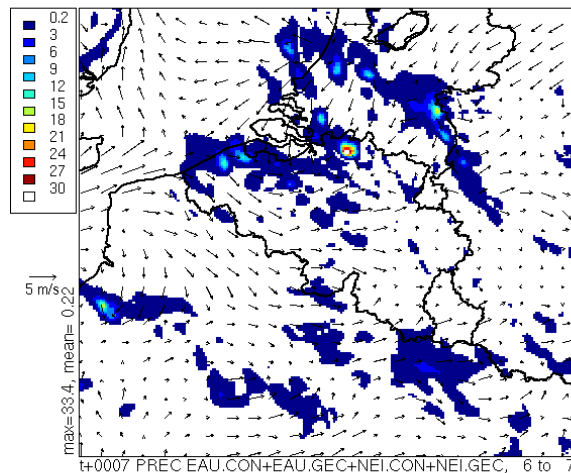
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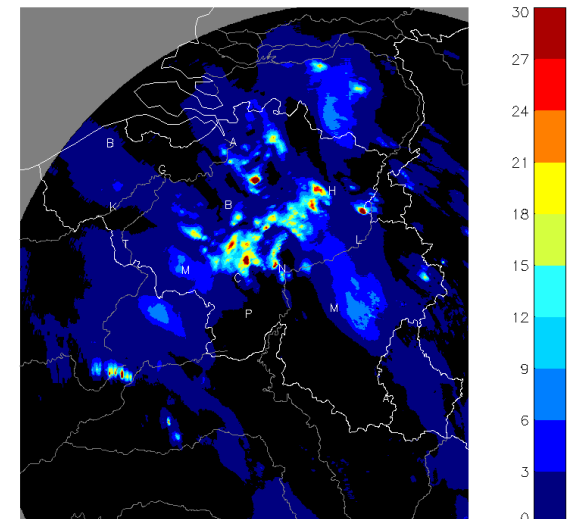
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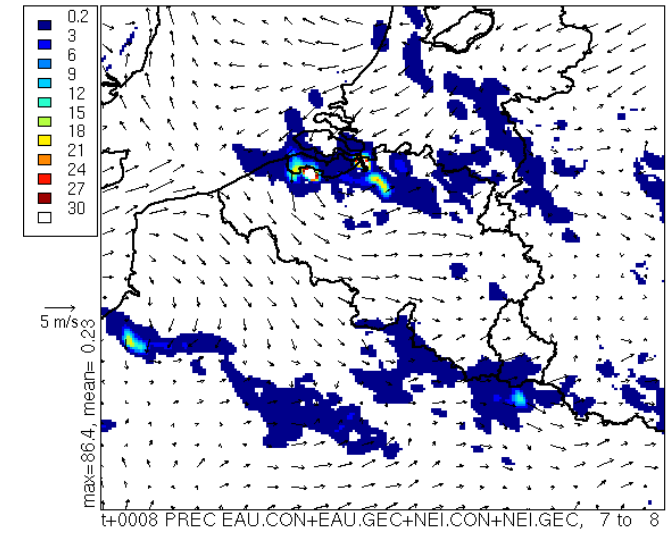
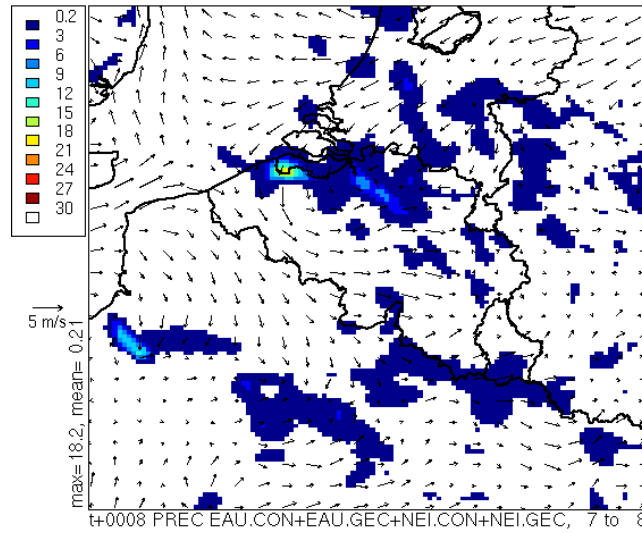
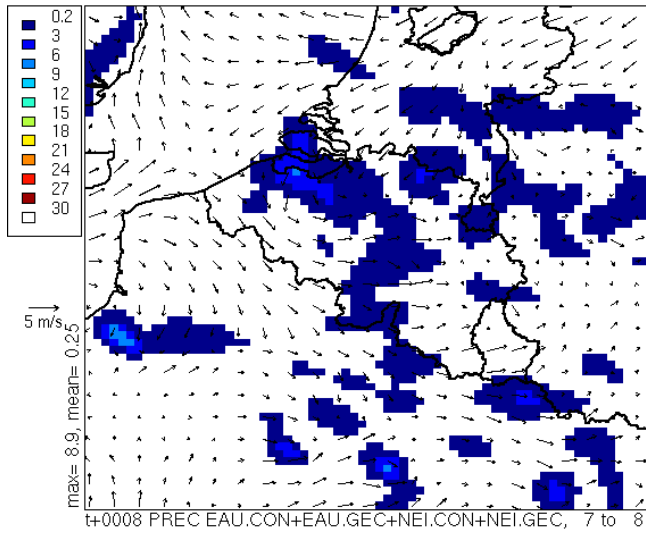


# Examples of prediction charts : thunderstorms, 10/09/2005

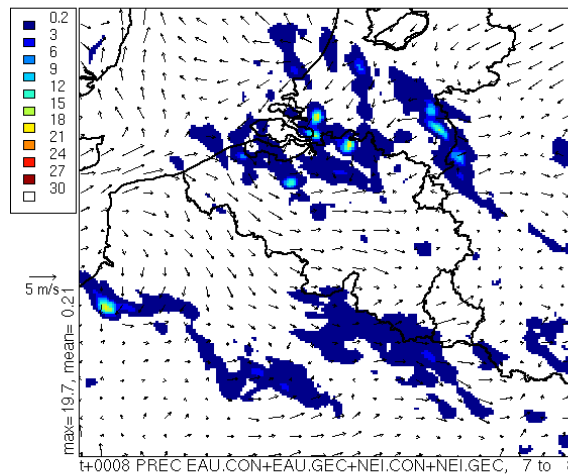
tA7vl : 2005/9/10 z12:0 +8h

tA4vl : 2005/9/10 z12:0 +8h

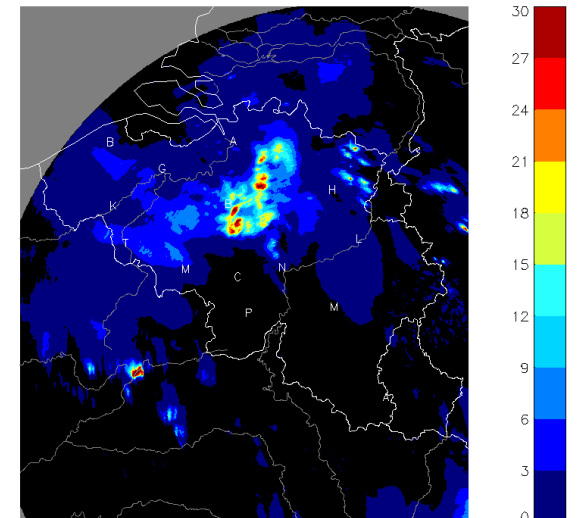
tA2vl : 2005/9/10 z12:0 +8h



tA2vl\_nh : 2005/9/10 z12:0 +8h



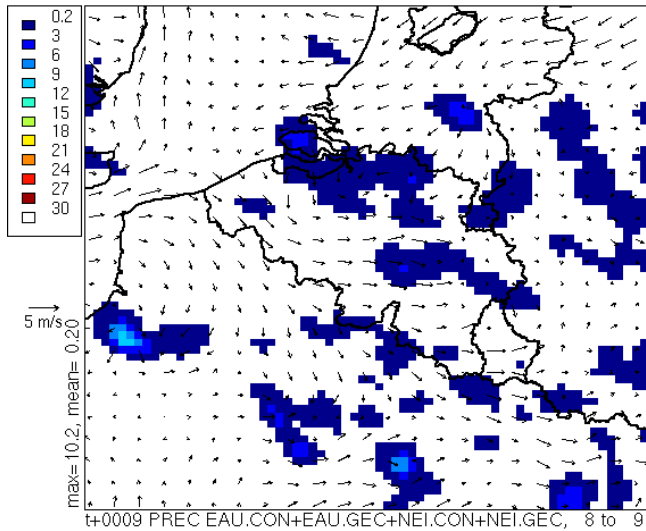
1h radar precipitation accumulation (mm) Starting at 10/09/2005 19 UT 12 /12 Radar Wideumont RMI - Belgium



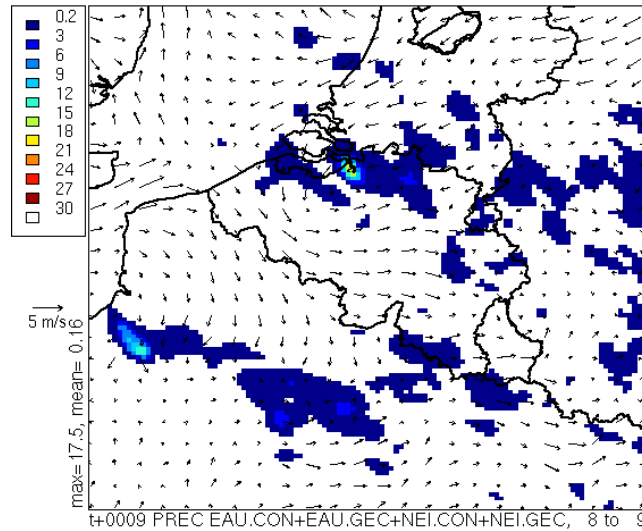


# Examples of prediction charts : thunderstorms, 10/09/2005

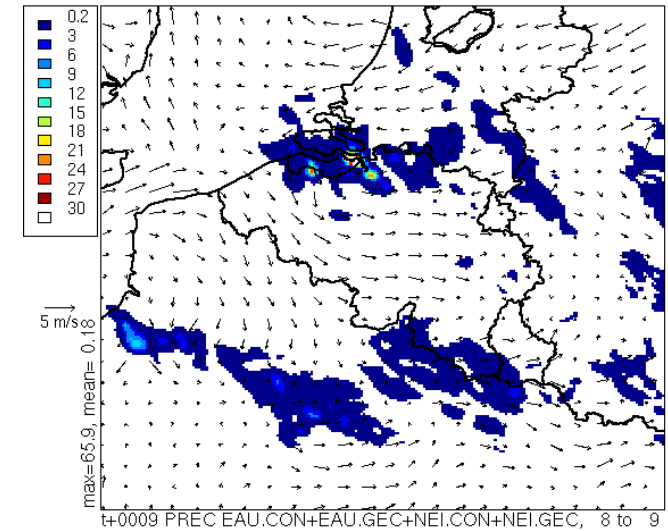
tA7vl : 2005/9/10 z12:0 +9h



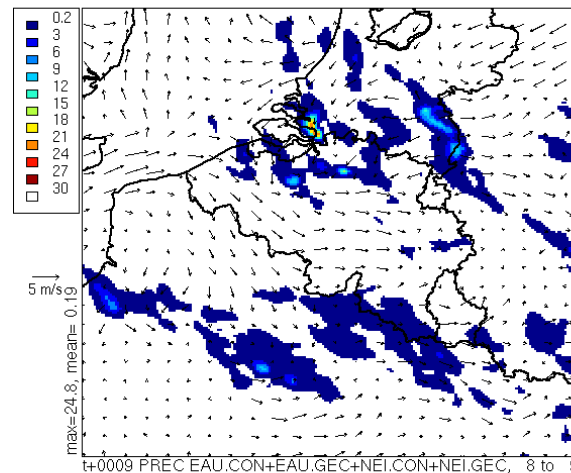
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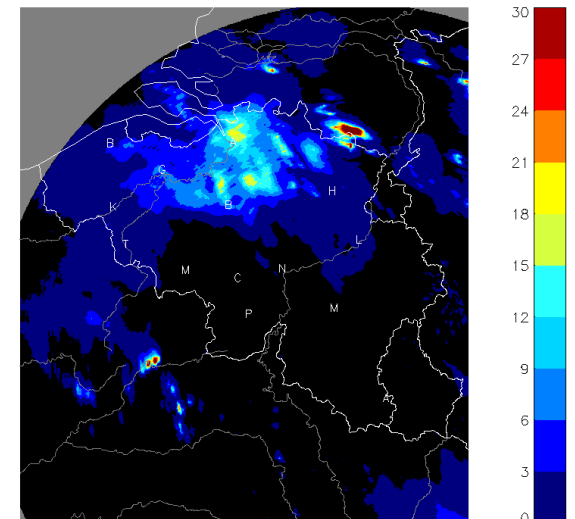
tA2vl : 2005/9/10 z12:0 +9h



tA2vl\_nh : 2005/9/10 z12:0 +9h

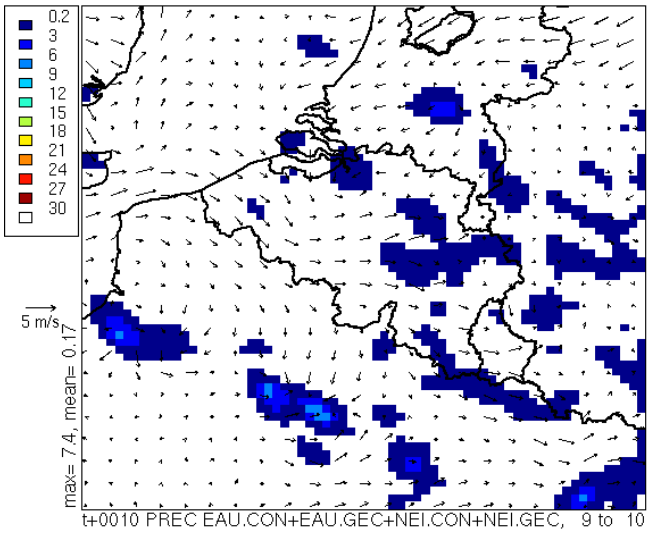


1h radar precipitation accumulation (mm) Starting at 10/09/2005 20 UT 12 / 12 Radar Wideumont RMI - Belgium

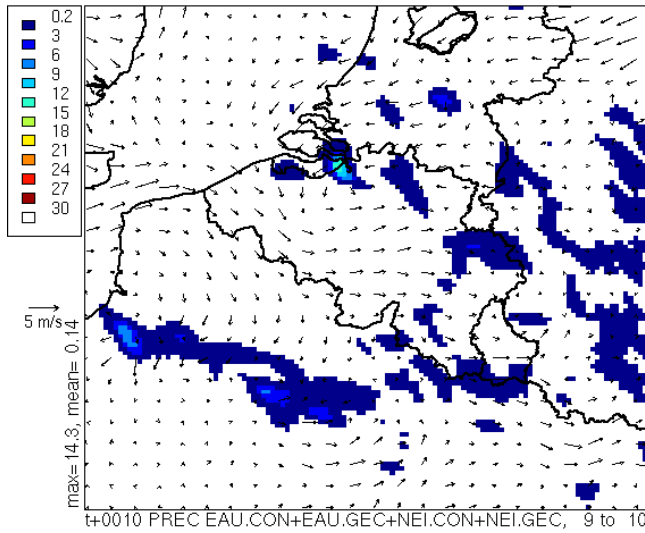


# Examples of prediction charts : thunderstorms, 10/09/2005

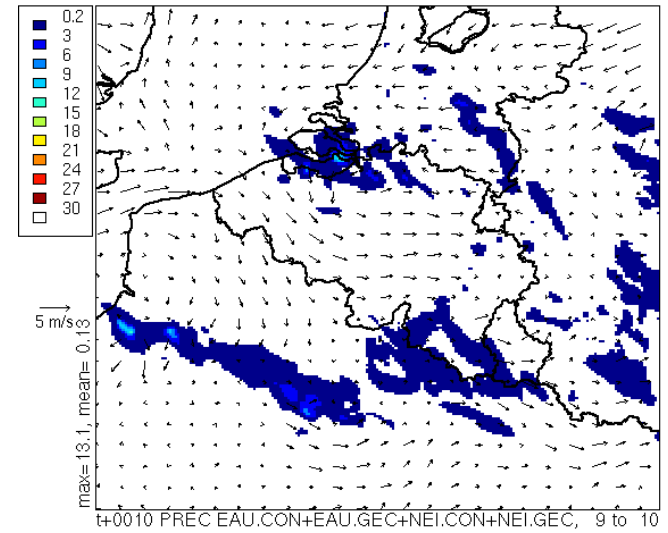
tA7vl : 2005/9/10 z12:0 +10h



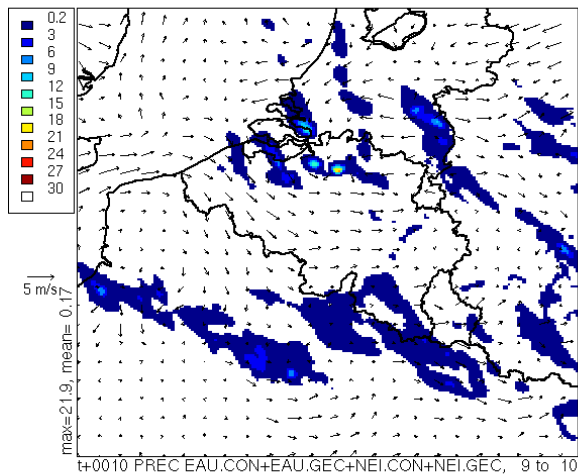
tA4vl : 2005/9/10 z12:0 +10h



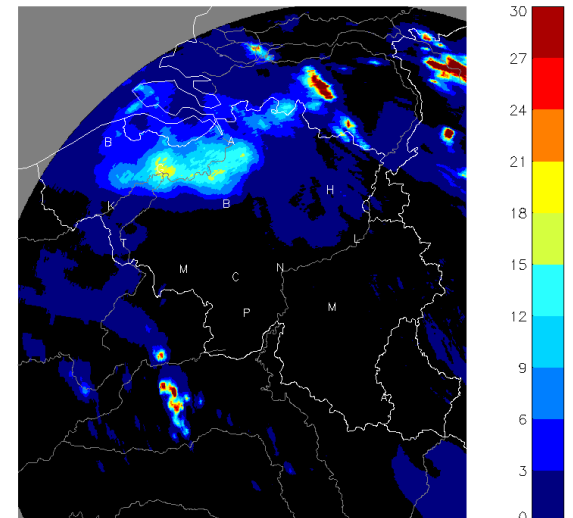
tA2vl : 2005/9/10 z12:0 +10h



tA2vl\_nh : 2005/9/10 z12:0 +10h

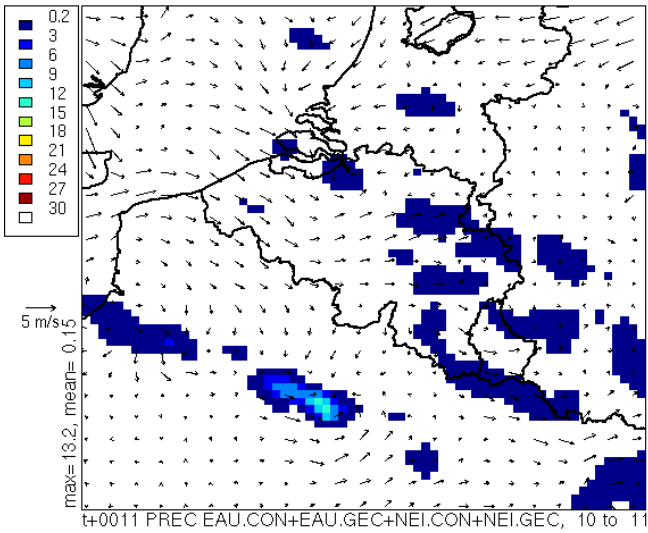


1h radar precipitation accumulation (mm) Starting at 10/09/2005 21 UT 12 /12 Radar Wideumont RMI - Belgium

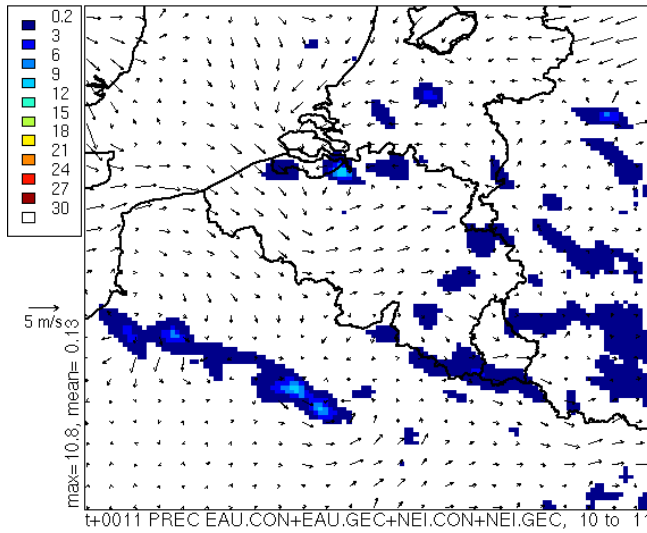


# Examples of prediction charts : thunderstorms, 10/09/2005

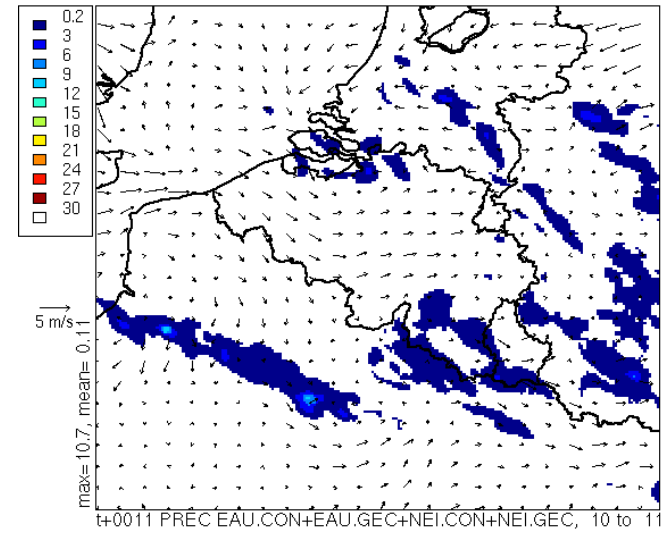
tA7vl : 2005/9/10 z12:0 +11h



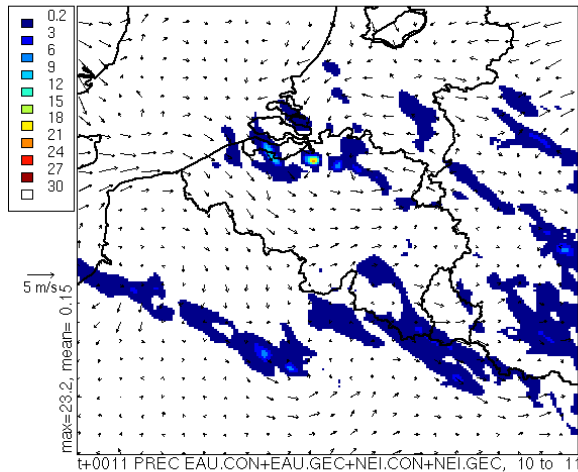
tA4vl : 2005/9/10 z12:0 +11h



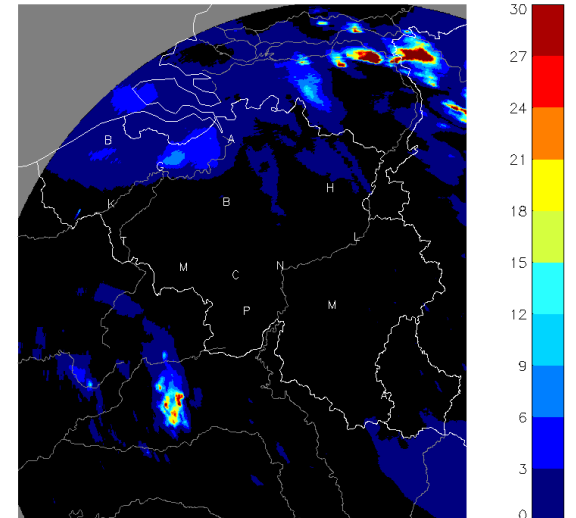
tA2vl : 2005/9/10 z12:0 +11h



tA2vl\_nh : 2005/9/10 z12:0 +11h

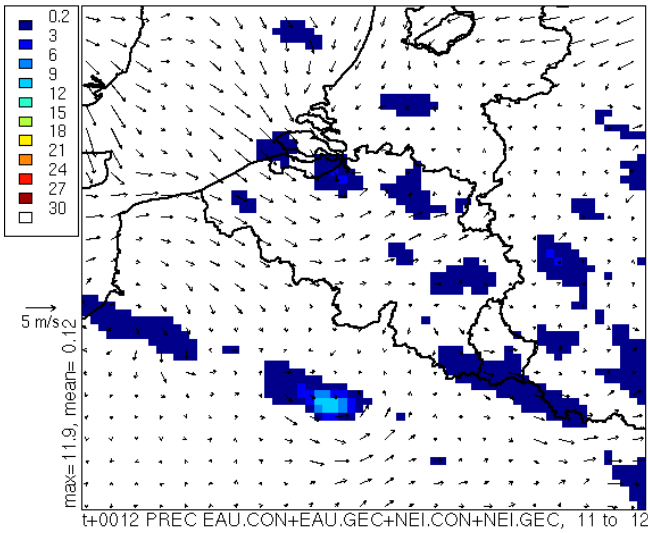


1h radar precipitation accumulation (mm) Starting at 10/09/2005 22 UT 12 /12 RMI - Belgium

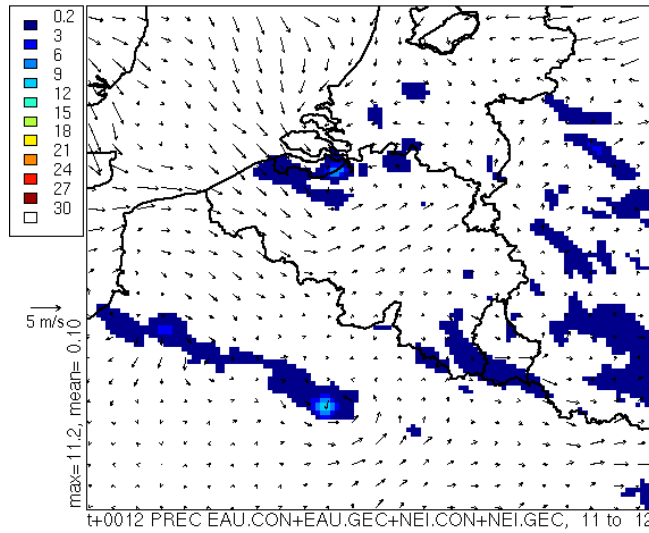


# Examples of prediction charts : thunderstorms, 10/09/2005

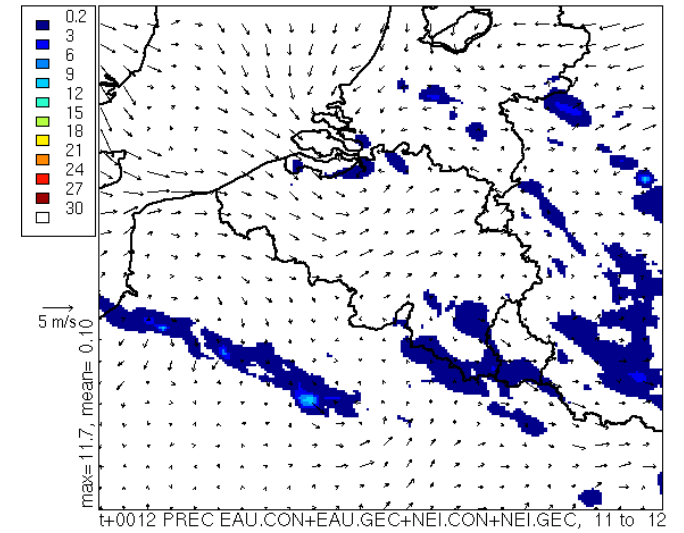
tA7vl : 2005/9/10 z12:0 +12h



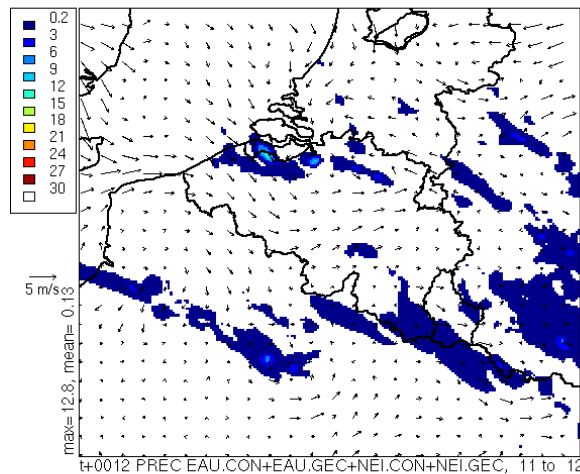
tA4vl : 2005/9/10 z12:0 +12h



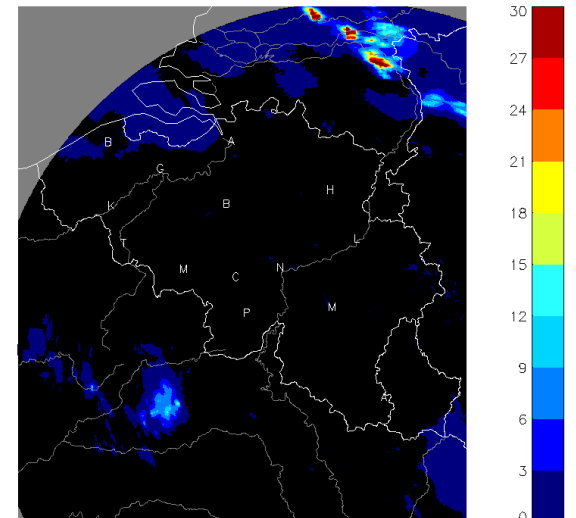
tA2vl : 2005/9/10 z12:0 +12h



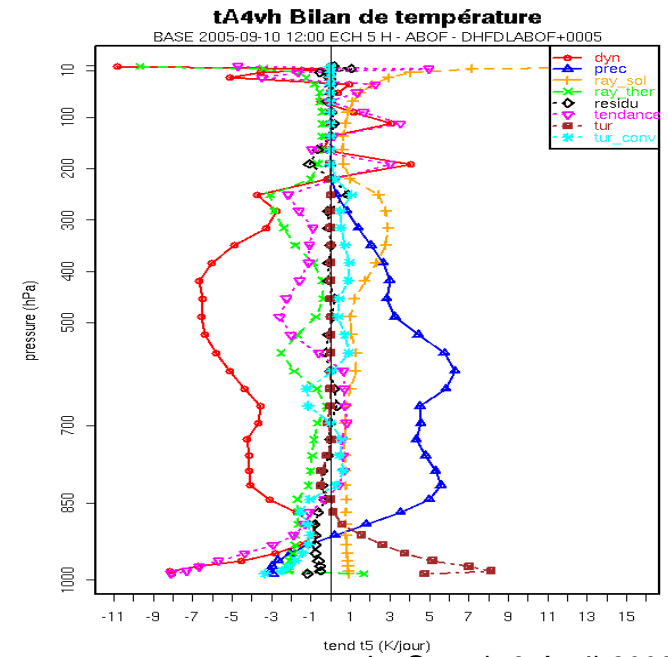
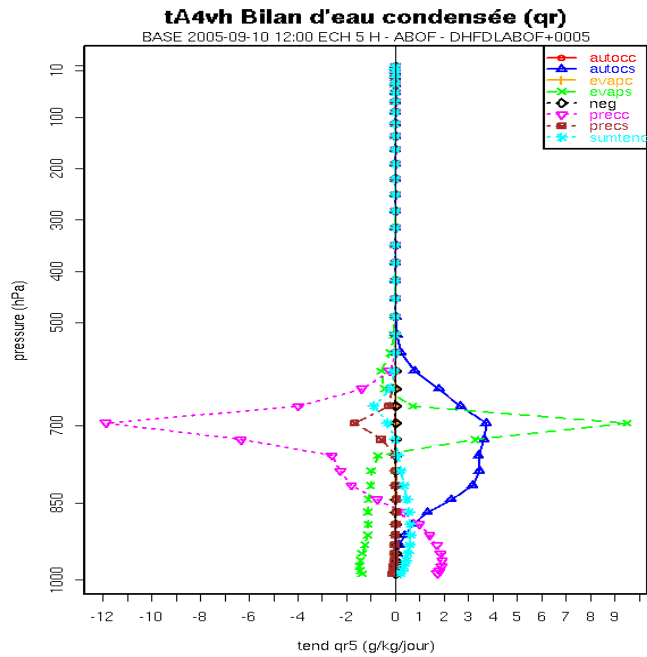
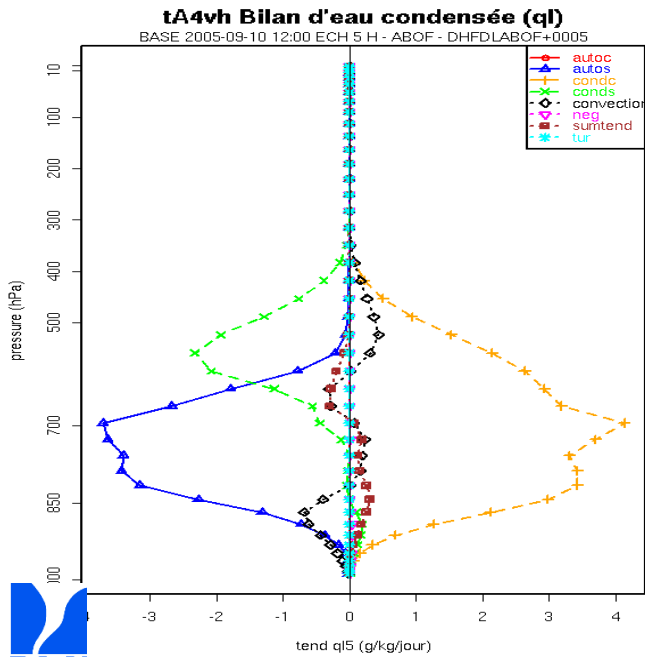
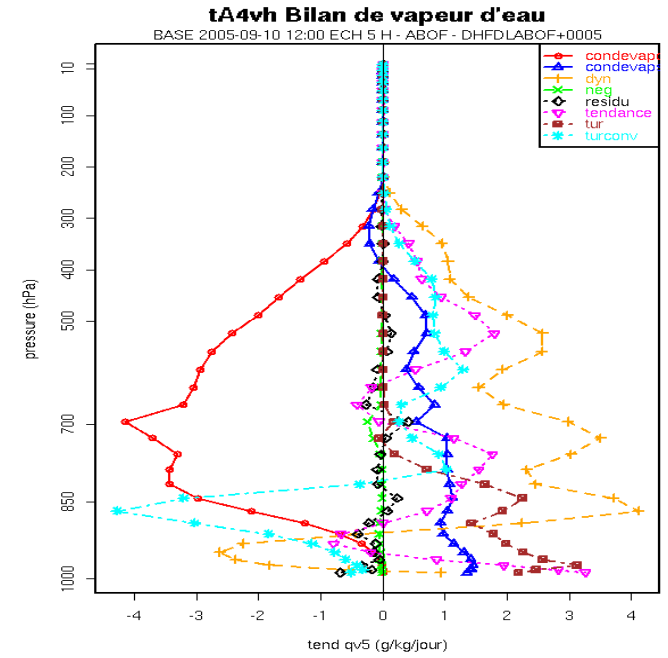
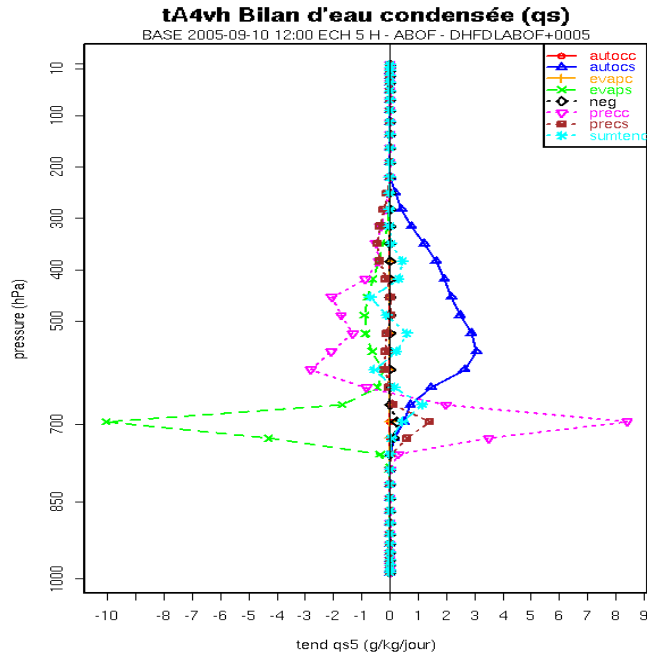
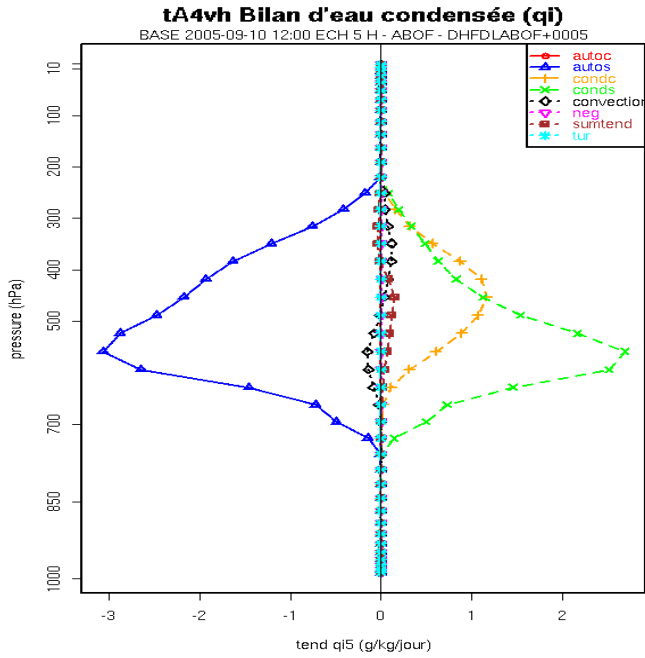
tA2vl\_nh : 2005/9/10 z12:0 +12h



1h radar precipitation accumulation (mm) Starting at 10/09/2005 23 UT 12 /12 RMI - Belgium



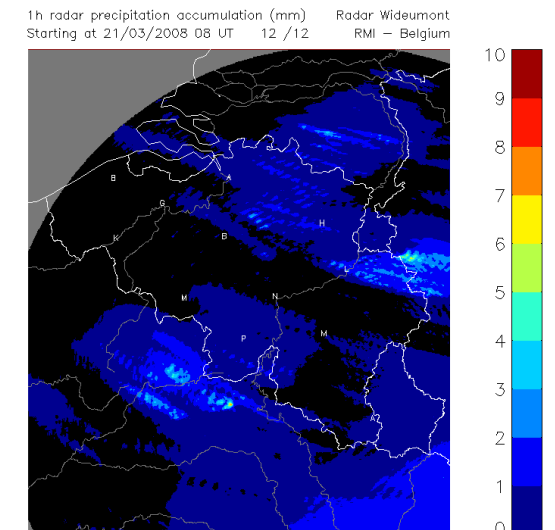
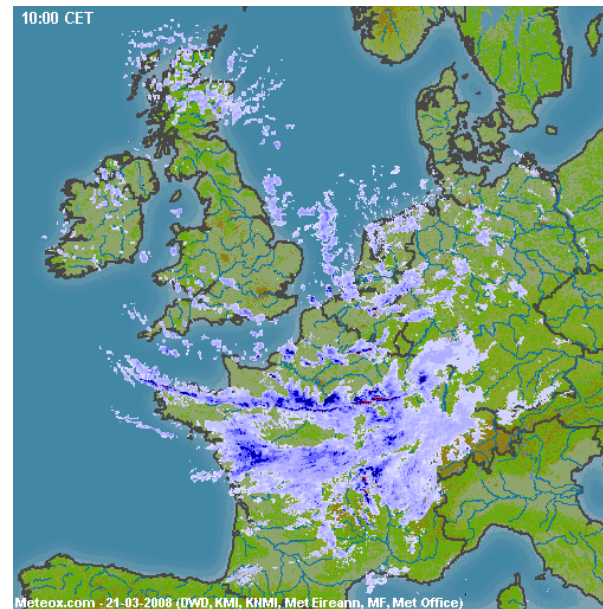
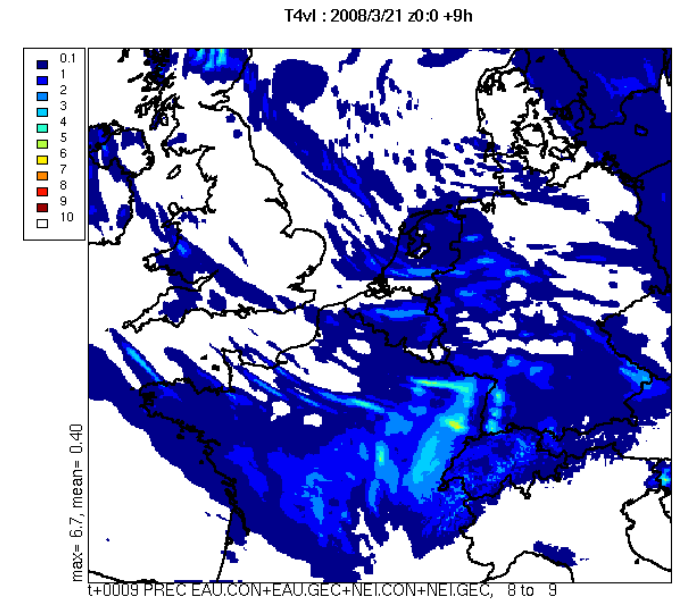
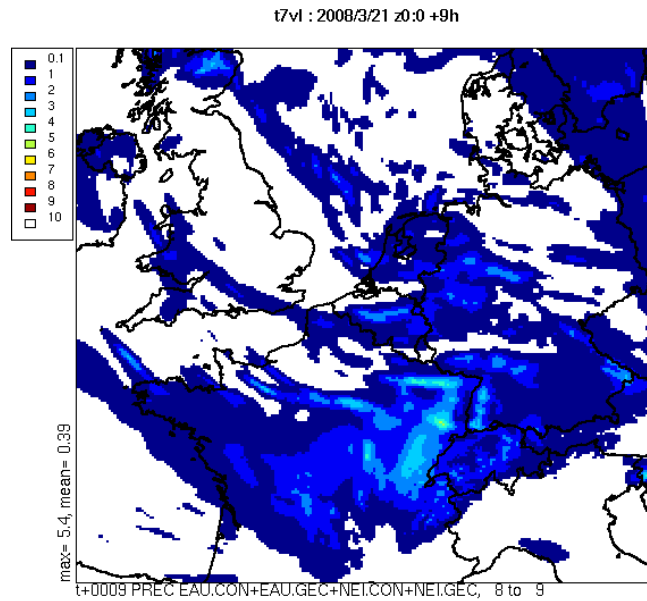
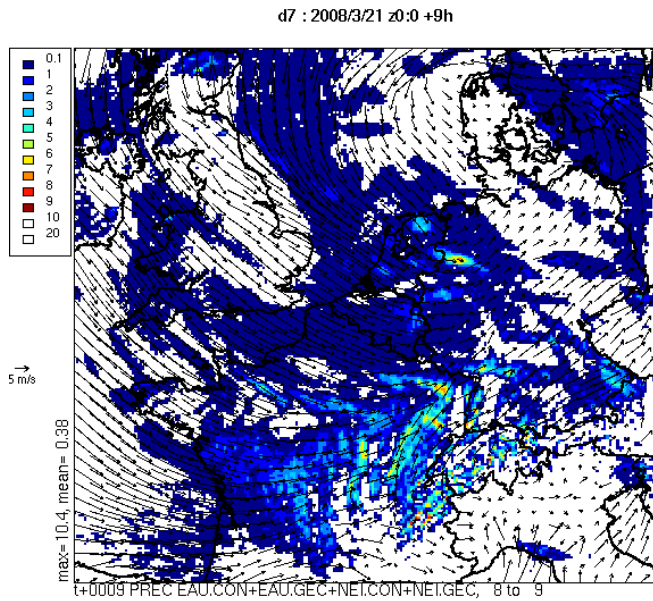
# DDH : Vertical profile of tendency components



# Examples of prediction charts : downpours, 21/03/2008

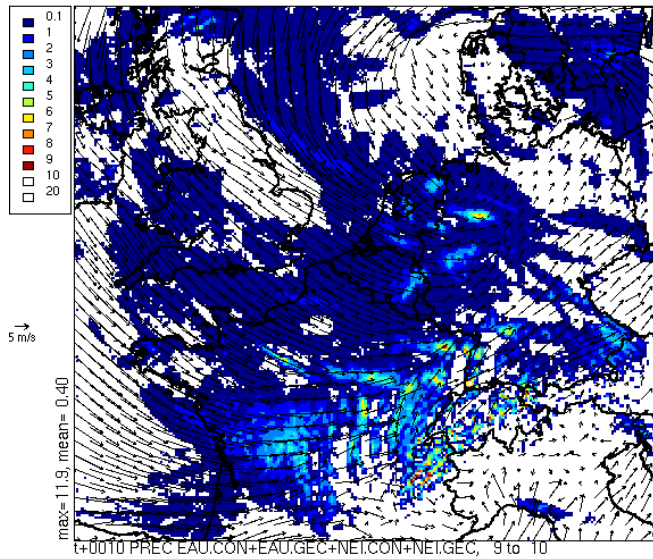


# Examples of prediction charts : downpours, 21/03/2008

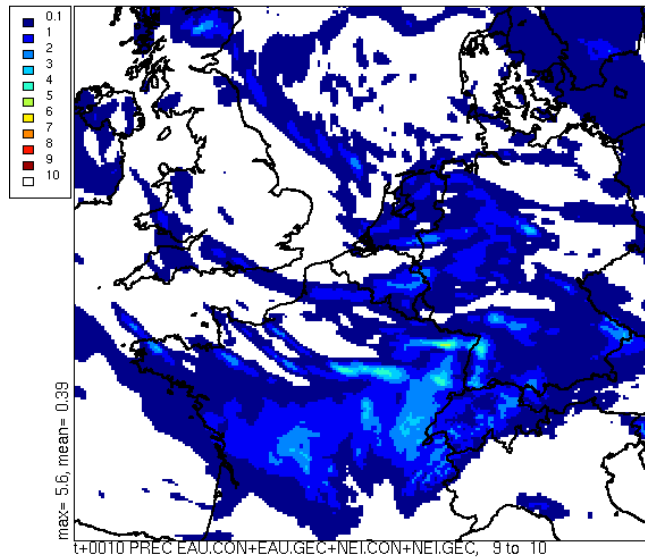


# Examples of prediction charts : downpours, 21/03/2008

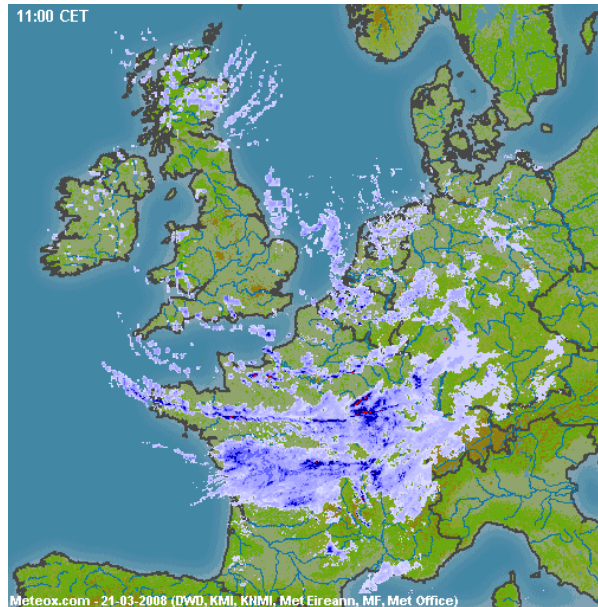
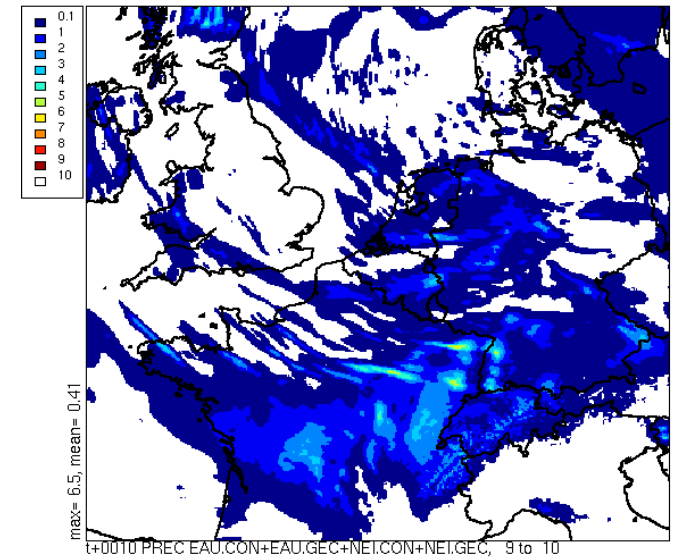
d7 : 2008/3/21 z0:0 +10h



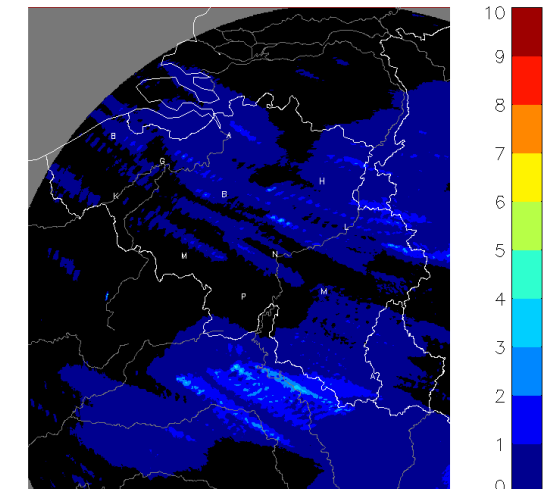
t7v1 : 2008/3/21 z0:0 +10h



T4v1 : 2008/3/21 z0:0 +10h



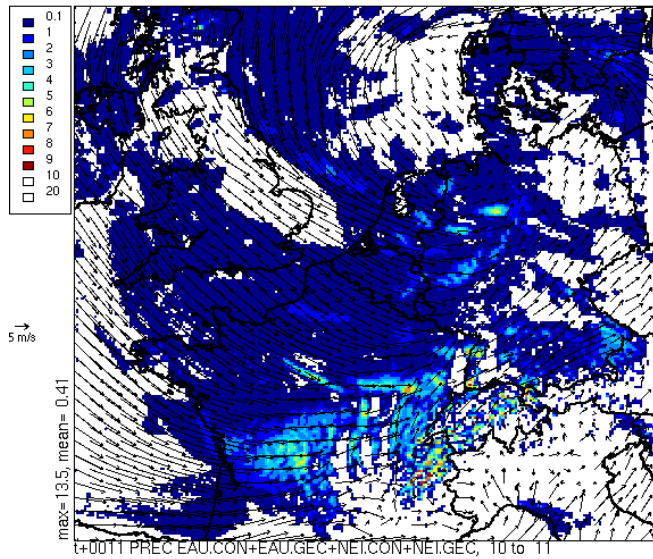
1h radar precipitation accumulation (mm) Starting at 21/03/2008 09 UT 12 /12 Radar Wideumont RMI - Belgium



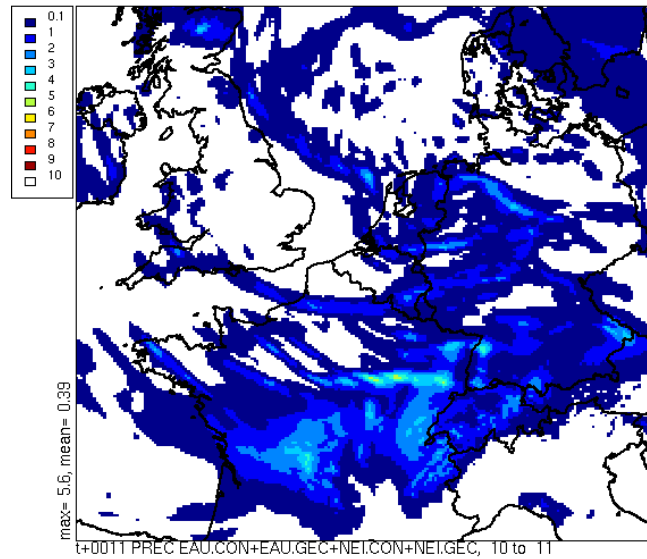


# Examples of prediction charts : downpours, 21/03/2008

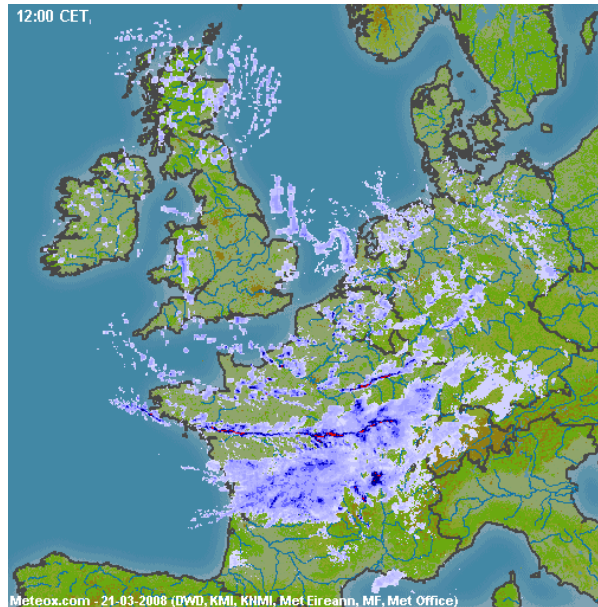
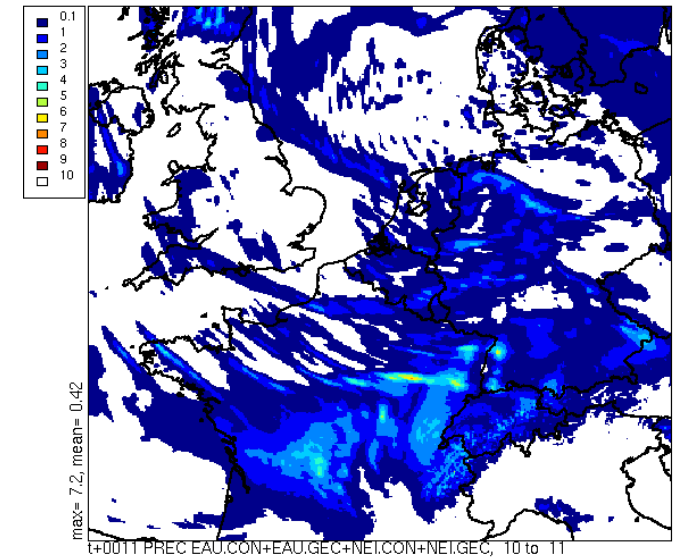
d7 : 2008/3/21 z0:0 +11h



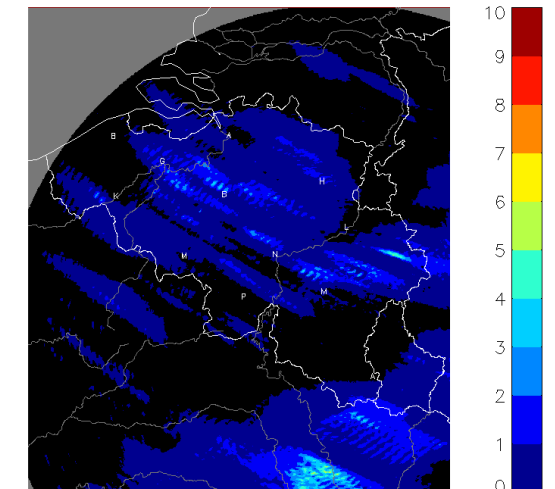
t7vl : 2008/3/21 z0:0 +11h



T4vl : 2008/3/21 z0:0 +11h

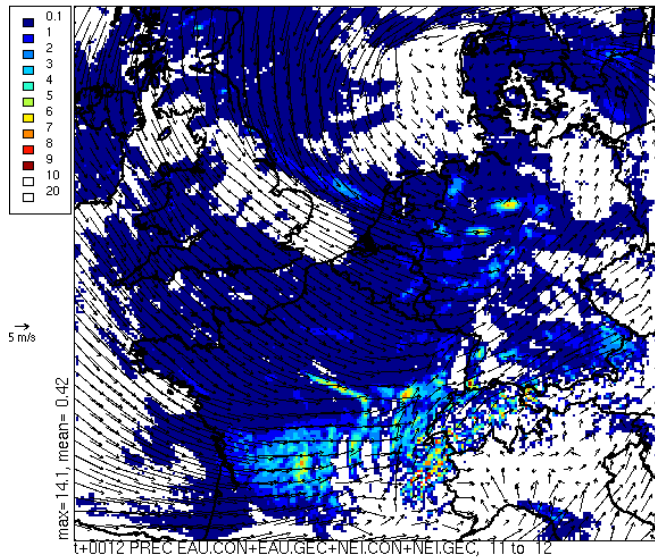


1h radar precipitation accumulation (mm) Starting at 21/03/2008 10 UT 12 /12

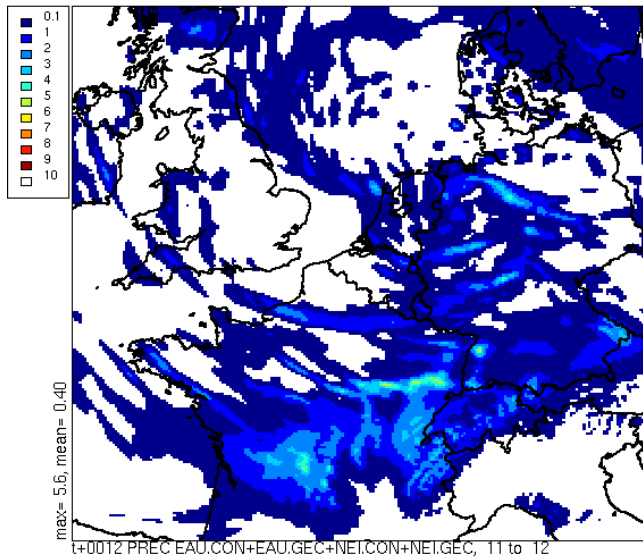


# Examples of prediction charts : downpours, 21/03/2008

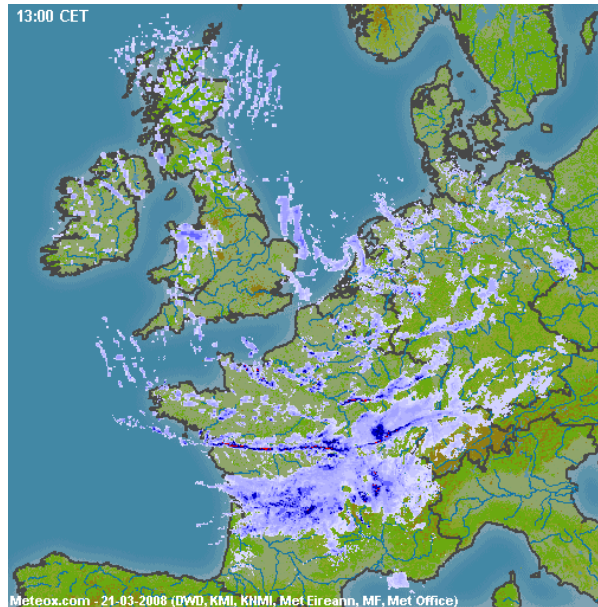
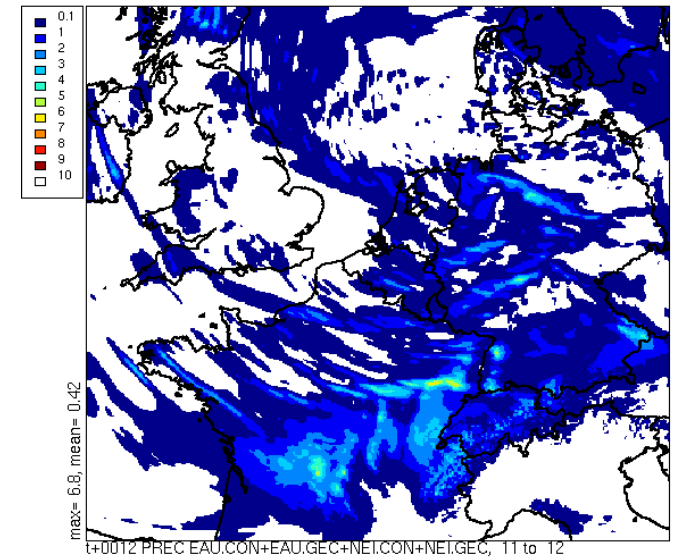
d7 : 2008/3/21 z0:0 +12h



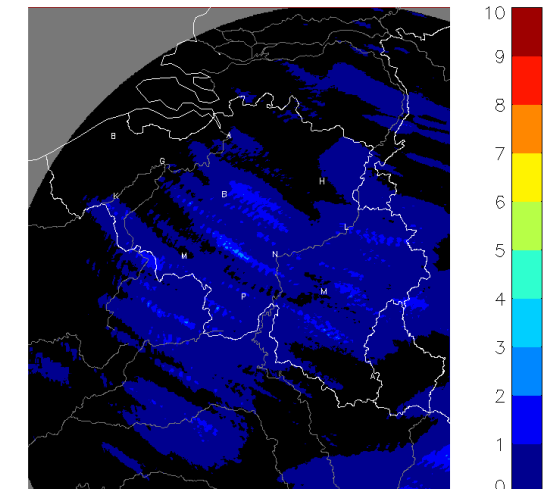
t7vl : 2008/3/21 z0:0 +12h



T4vl : 2008/3/21 z0:0 +12h



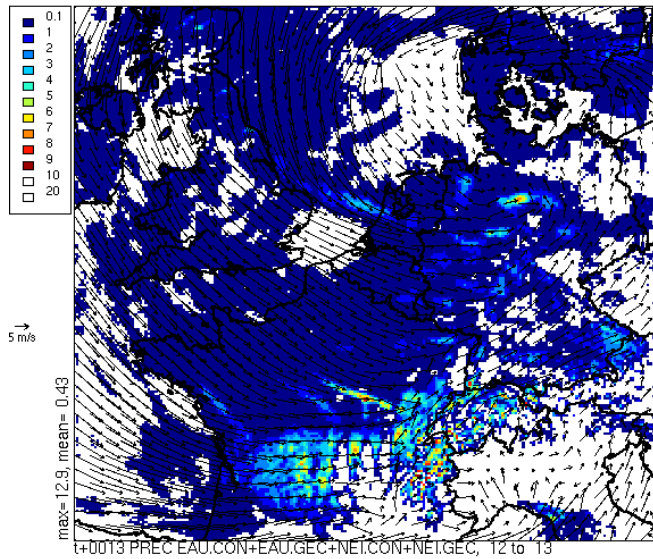
1h radar precipitation accumulation (mm) Starting at 21/03/2008 11 UT 12 /12 Radar Wideumont RMI - Belgium



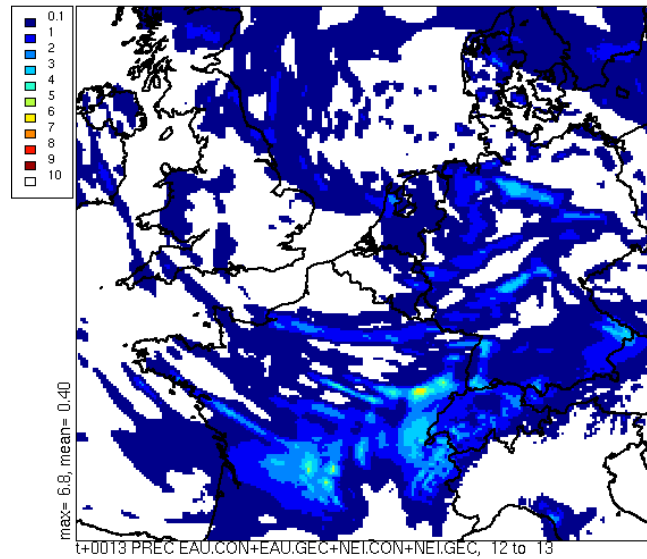


# Examples of prediction charts : downpours, 21/03/2008

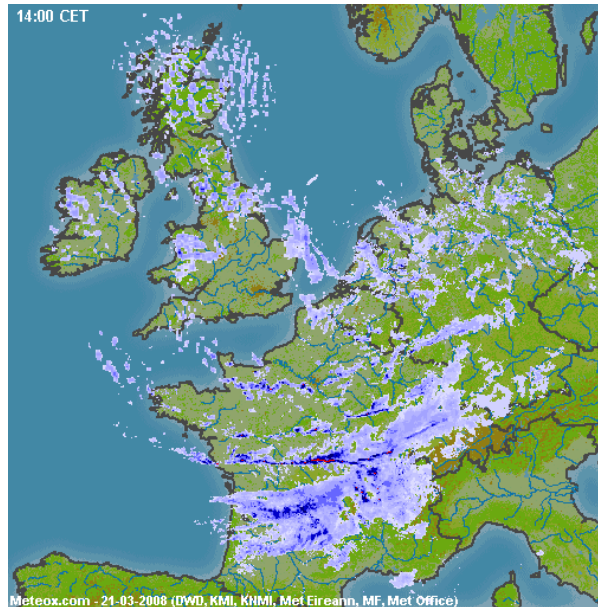
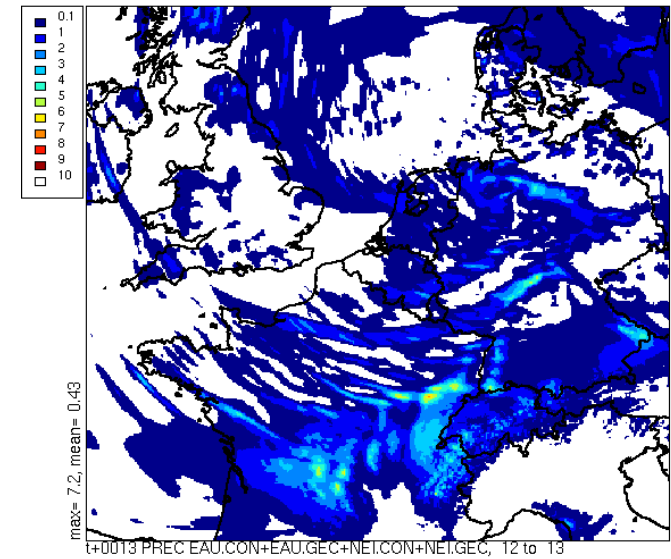
d7 : 2008/3/21 z0:0 +13h



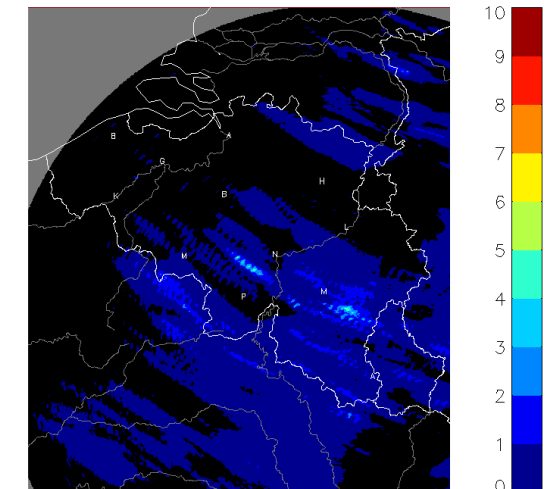
t7vl : 2008/3/21 z0:0 +13h



T4vl : 2008/3/21 z0:0 +13h

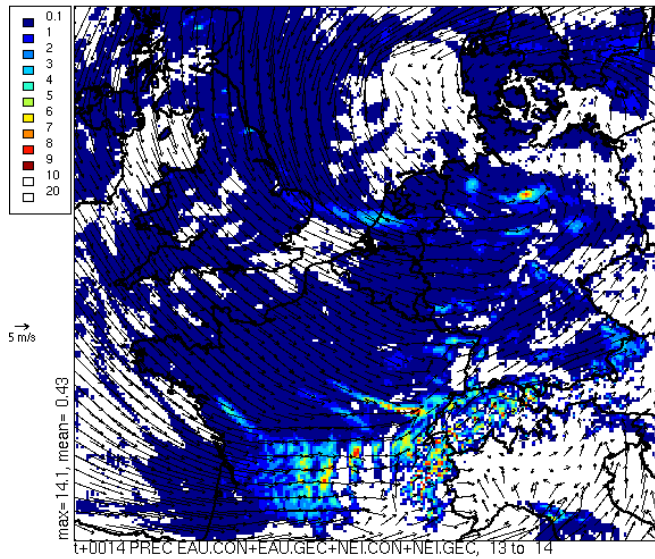


1h radar precipitation accumulation (mm) Starting at 21/03/2008 12 UT 12 /12 Radar Wideumont RMI - Belgium

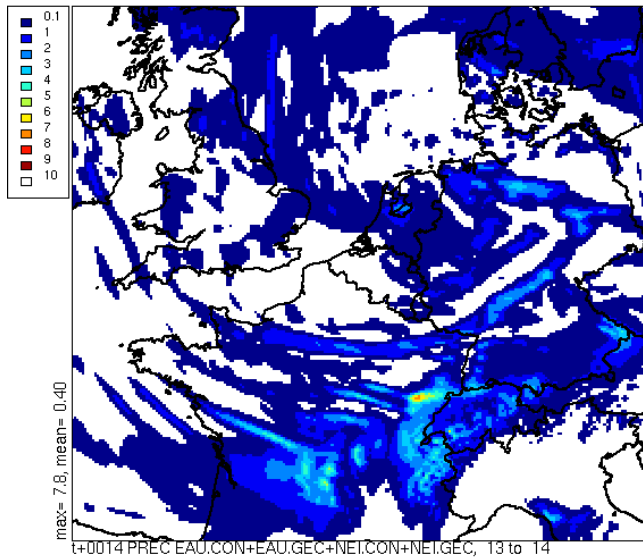


# Examples of prediction charts : downpours, 21/03/2008

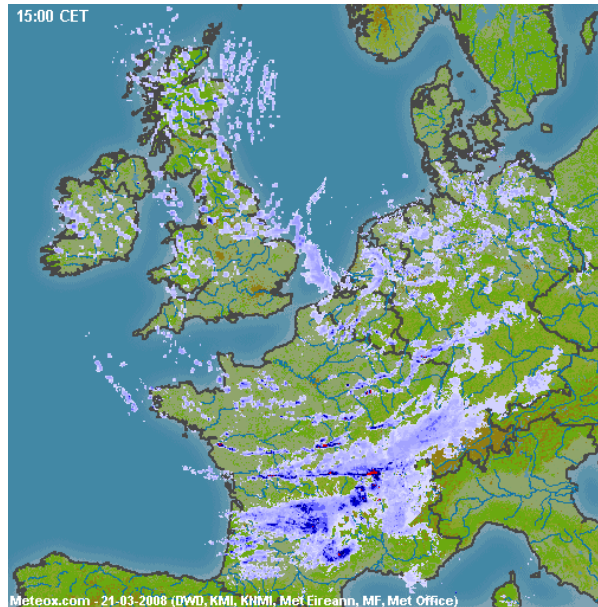
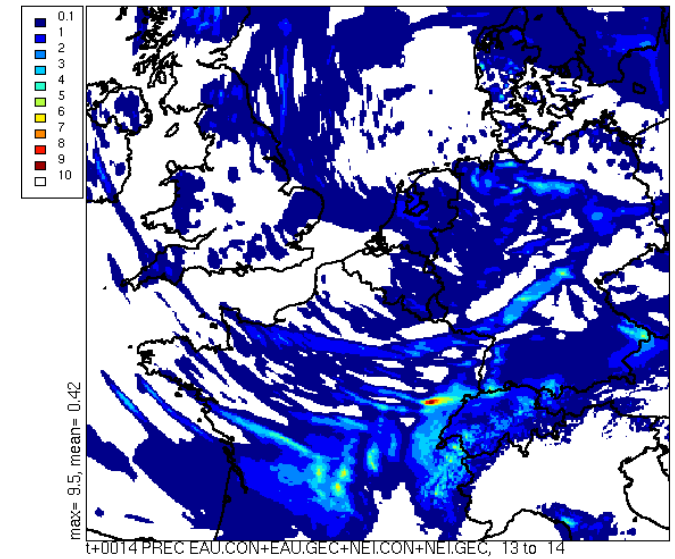
d7 : 2008/3/21 z0:0 +14h



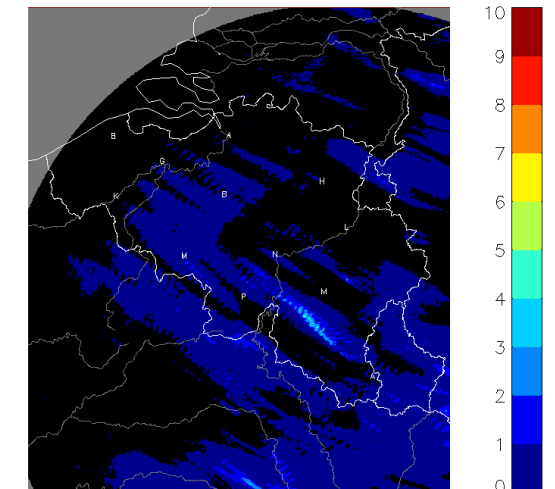
t7vi : 2008/3/21 z0:0 +14h



T4vi : 2008/3/21 z0:0 +14h



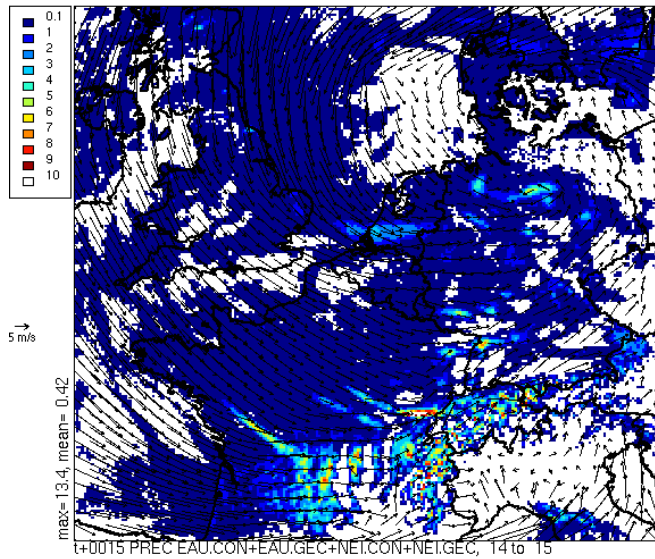
1h radar precipitation accumulation (mm) Starting at 21/03/2008 13 UT 12 /12 Radar Wideumont RMI - Belgium



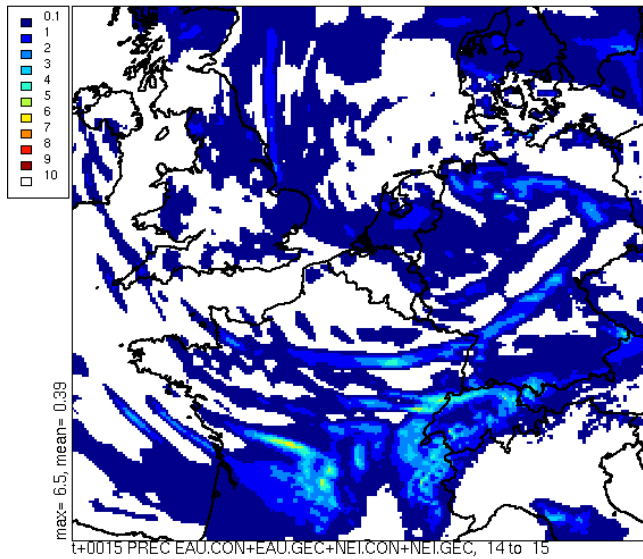


# Examples of prediction charts : downpours, 21/03/2008

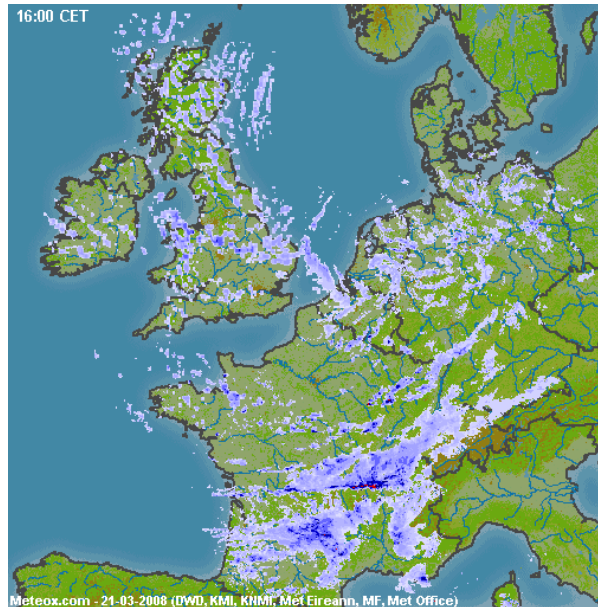
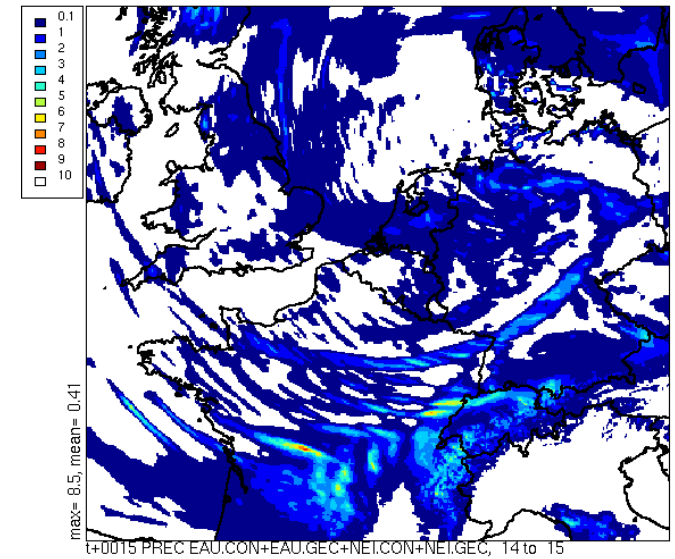
d7 : 2008/3/21 z0:0 +15h



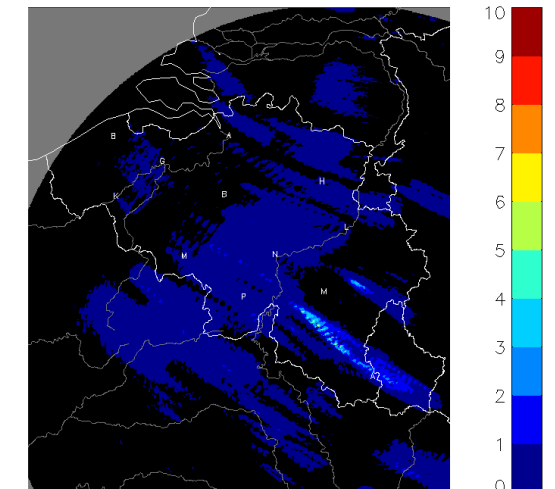
t7vl : 2008/3/21 z0:0 +15h



T4vl : 2008/3/21 z0:0 +15h

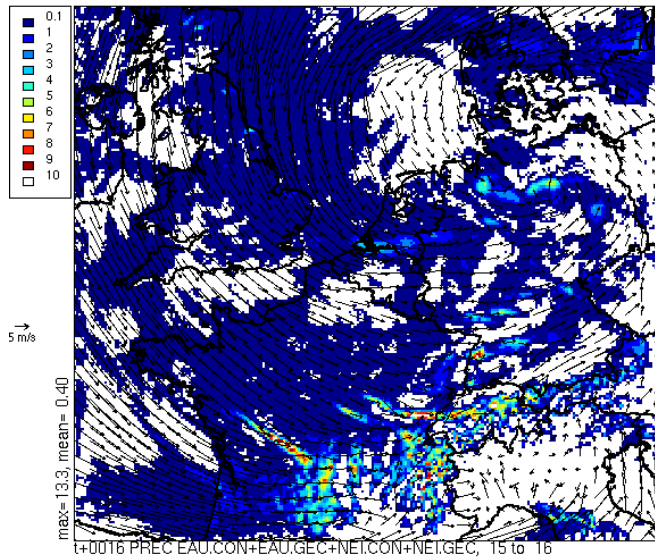


1h radar precipitation accumulation (mm) Starting at 21/03/2008 14 UT 12 /12

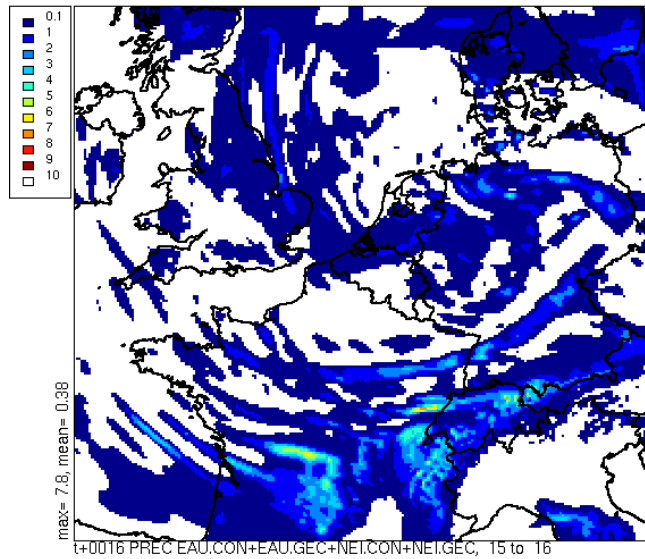


# Examples of prediction charts : downpours, 21/03/2008

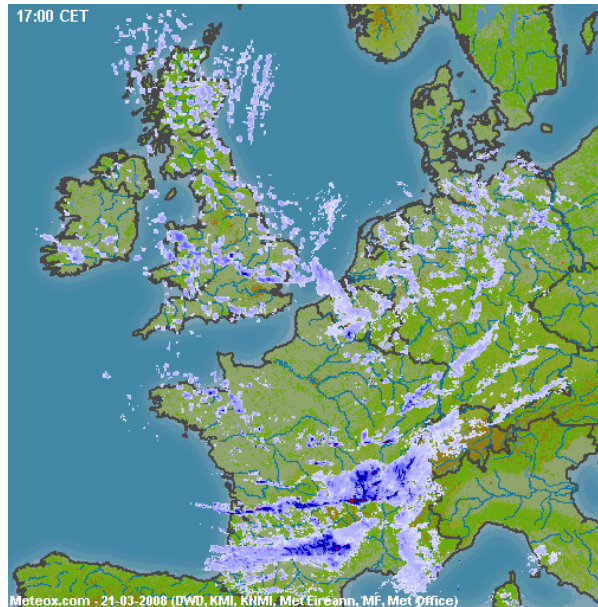
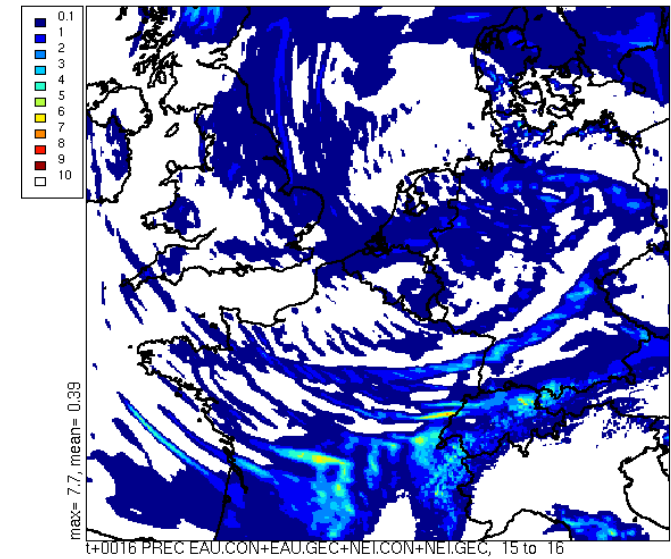
d7 : 2008/3/21 z0:0 +16h



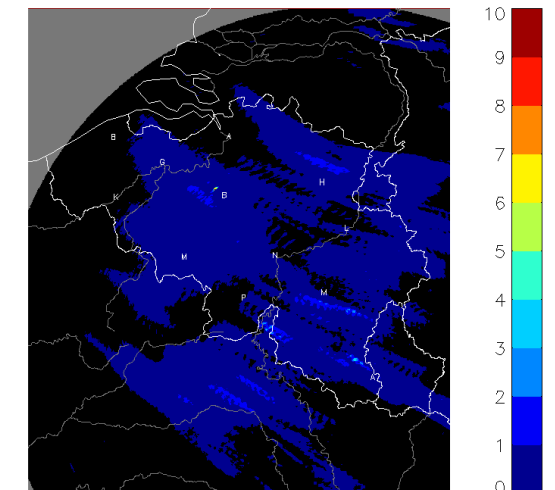
t7vl : 2008/3/21 z0:0 +16h



T4vl : 2008/3/21 z0:0 +16h



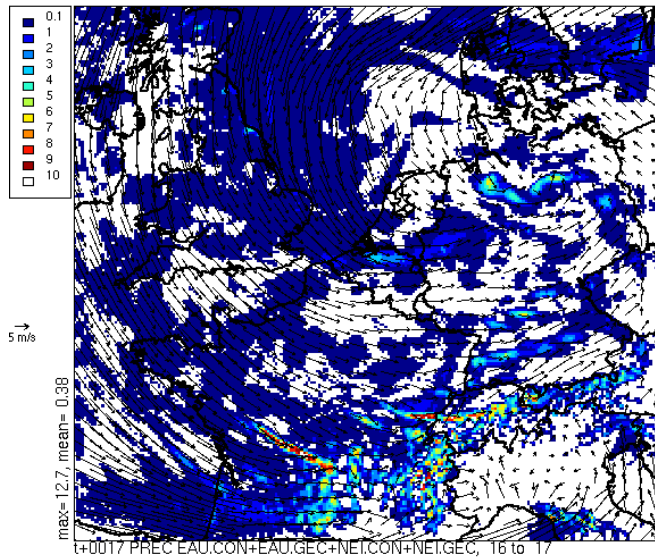
1h radar precipitation accumulation (mm) Starting at 21/03/2008 15 UT 12 /12 Radar Wideumont RMI - Belgium



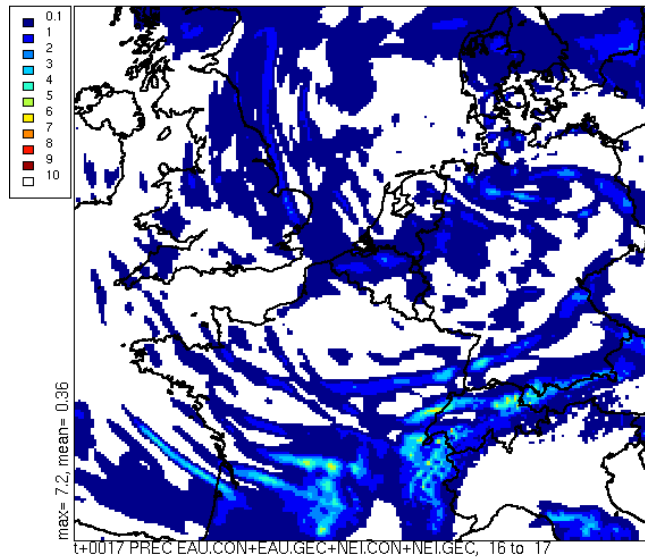


# Examples of prediction charts : downpours, 21/03/2008

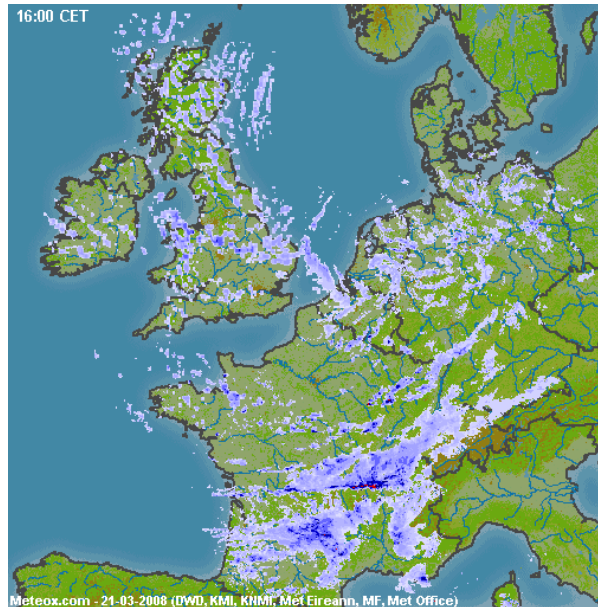
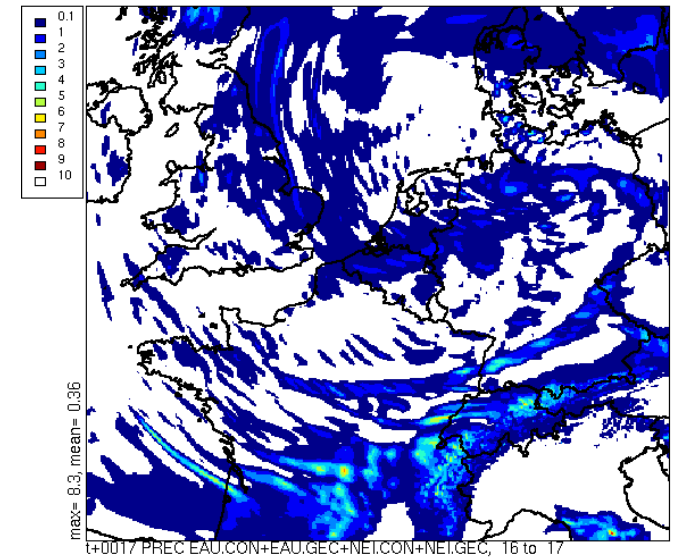
d7 : 2008/3/21 z0:0 +17h



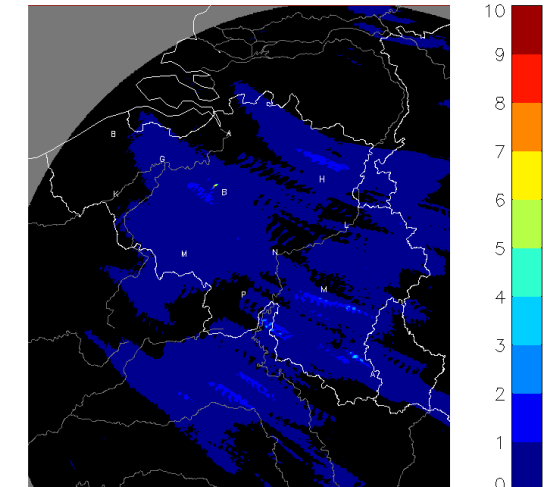
t7vl : 2008/3/21 z0:0 +17h



T4vl : 2008/3/21 z0:0 +17h



1h radar precipitation accumulation (mm)  
Starting at 21/03/2008 15 UT 12 /12  
RMI - Belgium

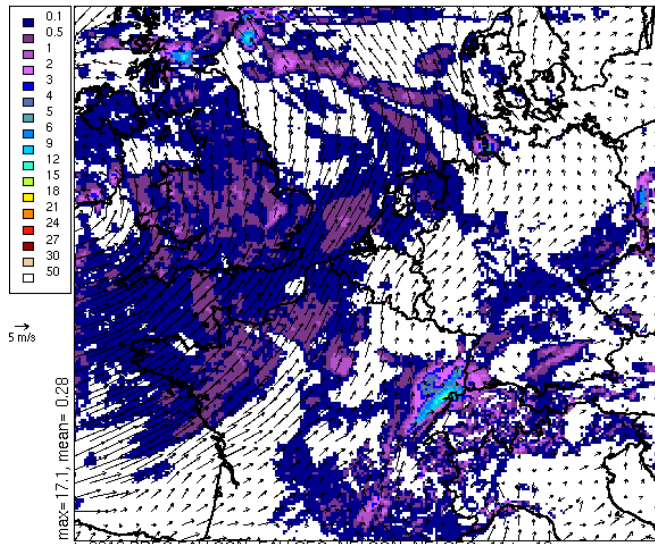


# Examples of prediction charts : squall lines 1/10/2006

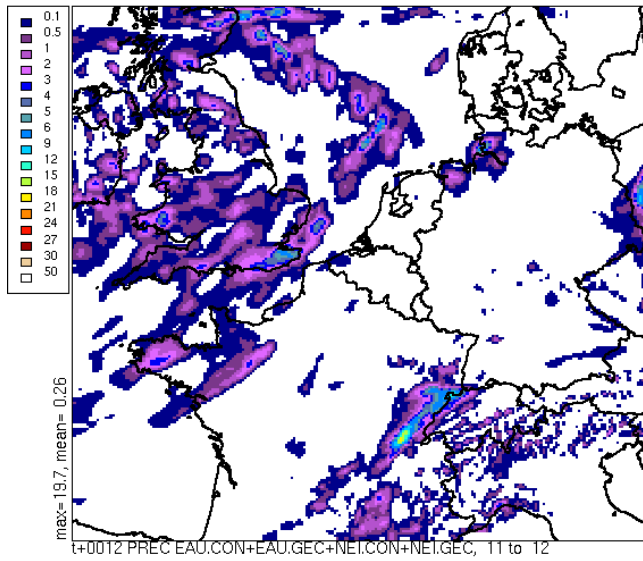


# Examples of prediction charts : squall lines 1/10/2006

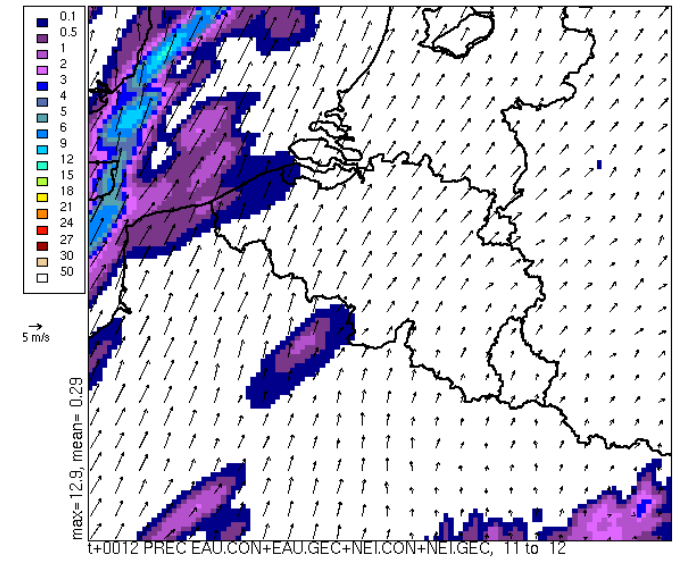
d7 : 2006/10/1 z0:0 +12h



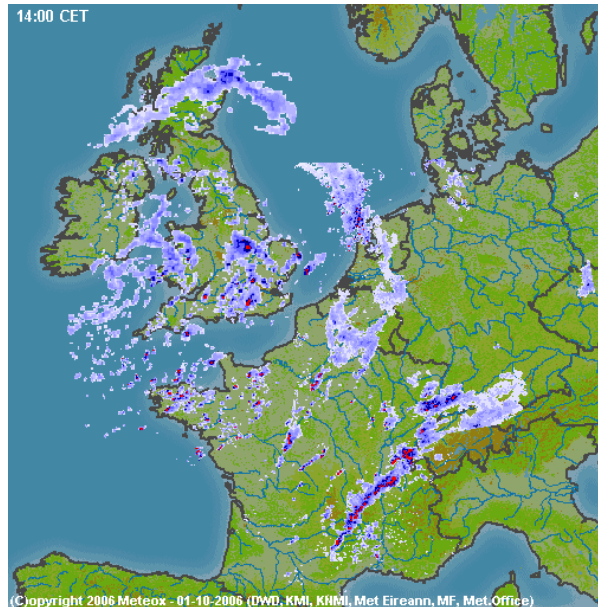
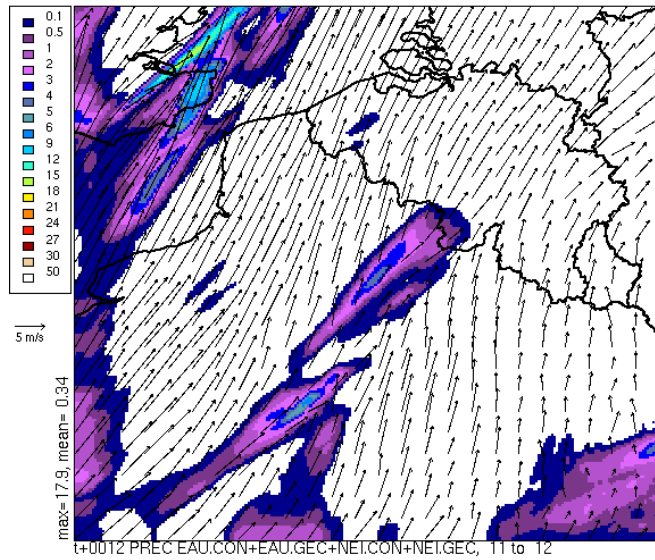
t7vl : 2006/10/1 z0:0 +12h



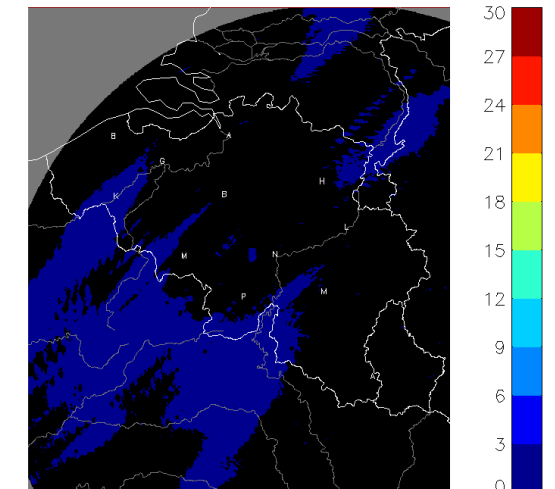
t4vl : 2006/10/1 z0:0 +12h



t2vl : 2006/10/1 z0:0 +12h

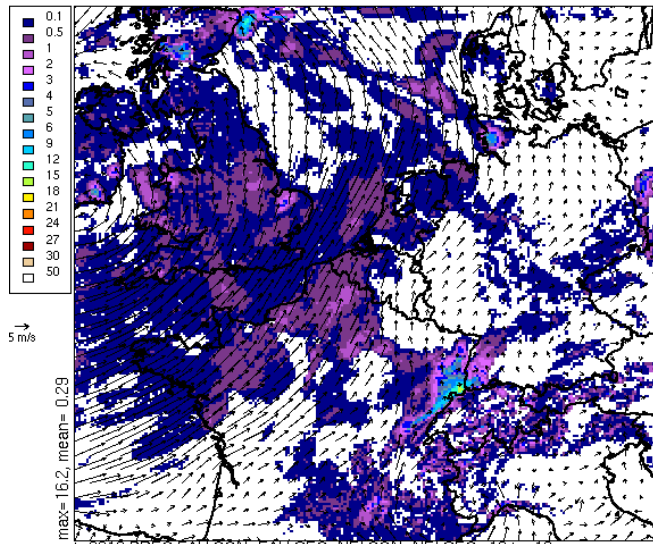


1h radar precipitation accumulation (mm) Starting at 01/10/2006 11 UT 12 /12 Radar Wideumont RMI - Belgium

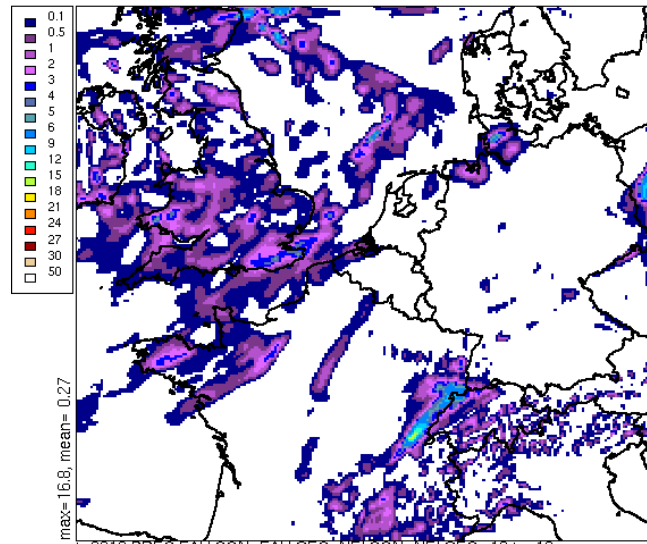


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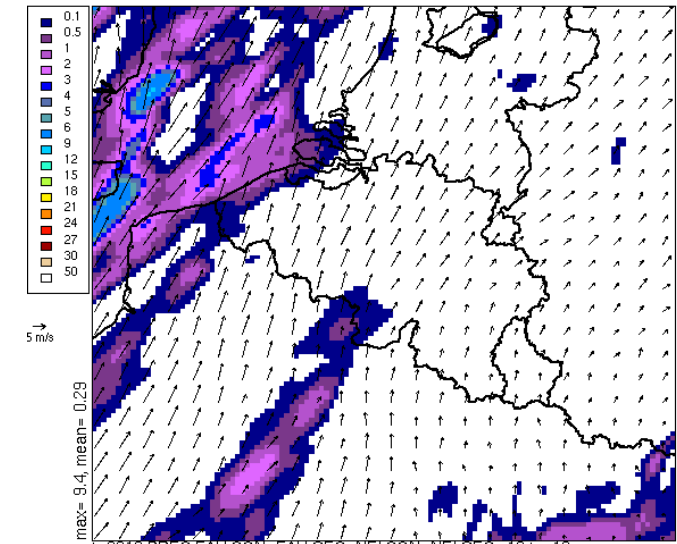
d7 : 2006/10/1 z0:0 +13h



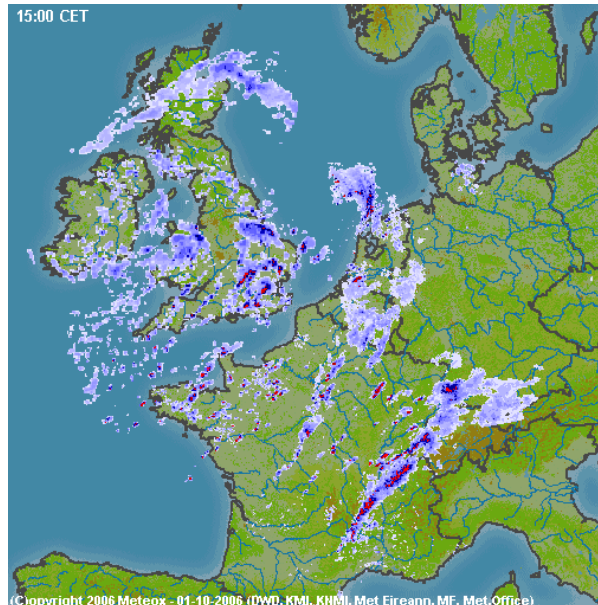
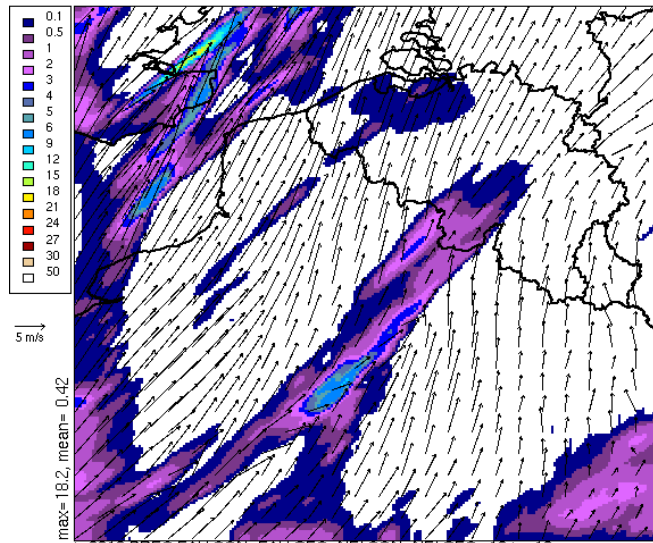
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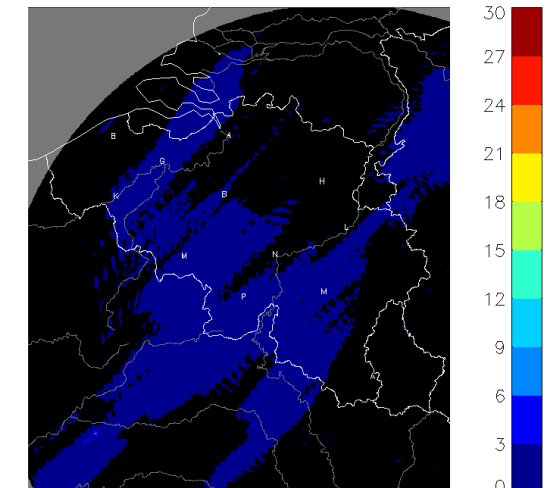
t4vl : 2006/10/1 z0:0 +13h



t2vl : 2006/10/1 z0:0 +13h



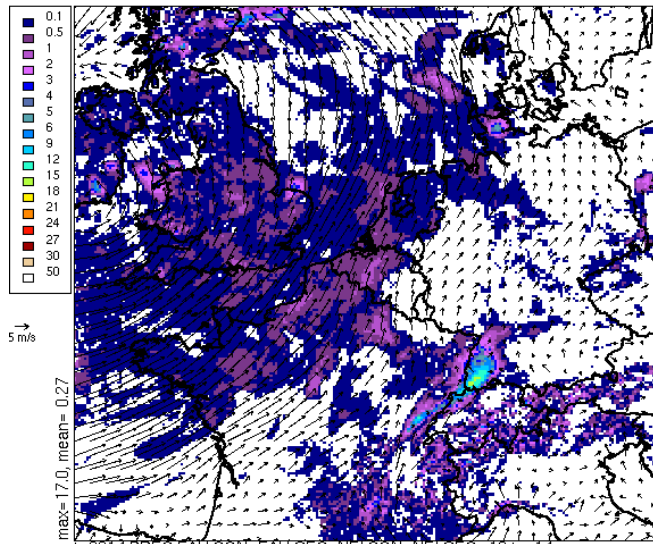
1h radar precipitation accumulation (mm) Starting at 01/10/2006 12 UT 12 /12 Radar Wideumont RMI - Belgium



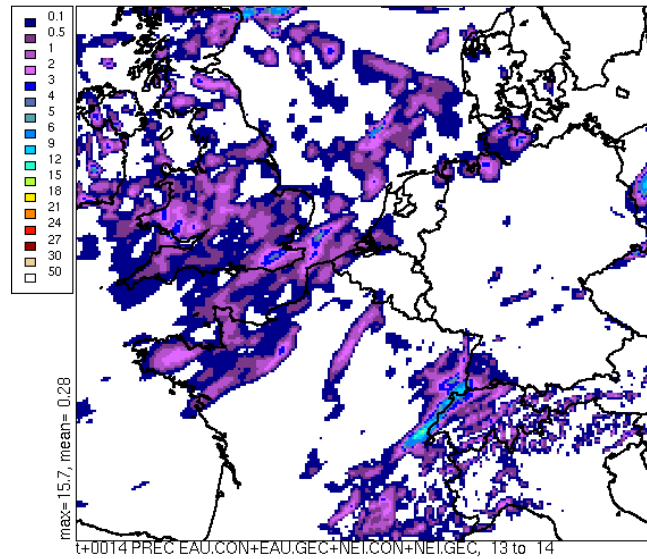


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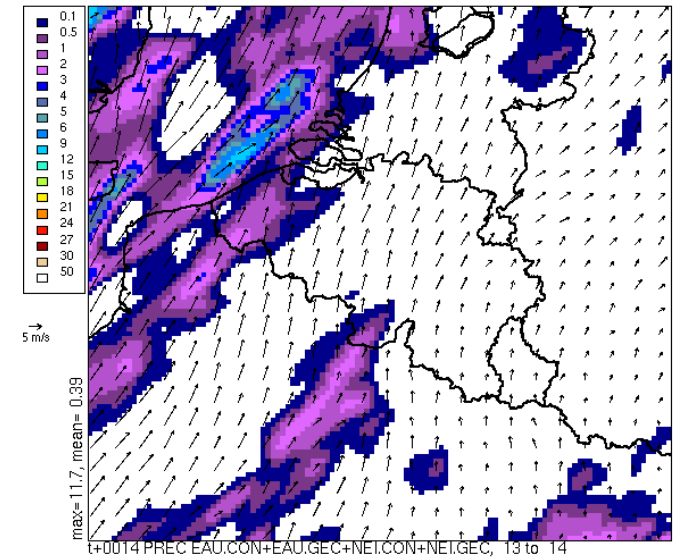
d7 : 2006/10/1 z0:0 +14h



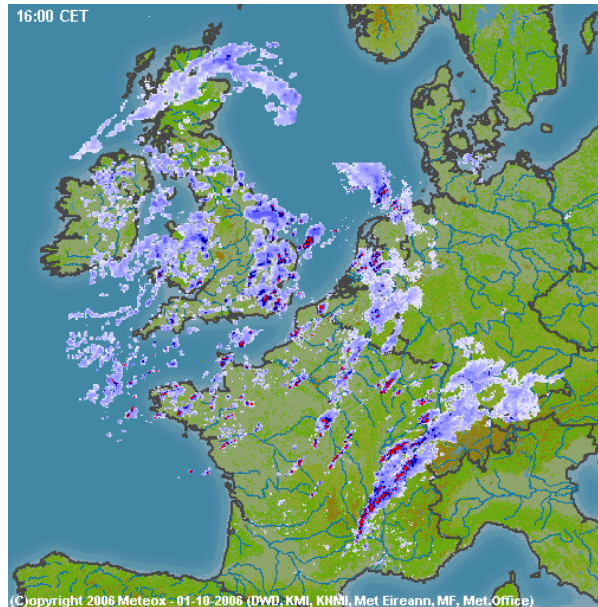
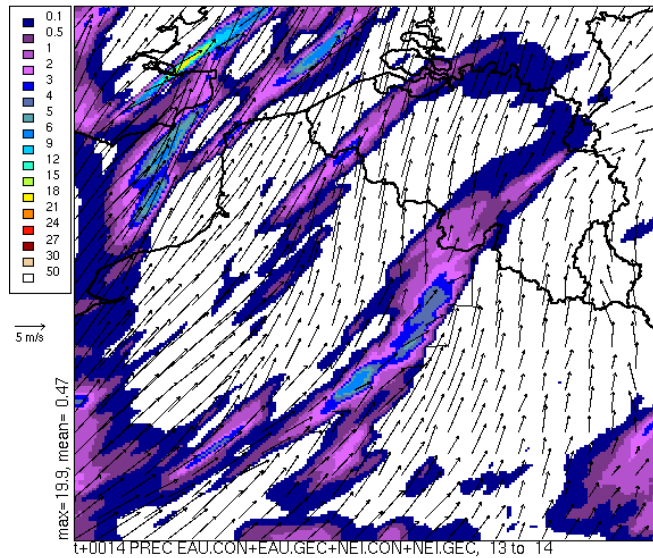
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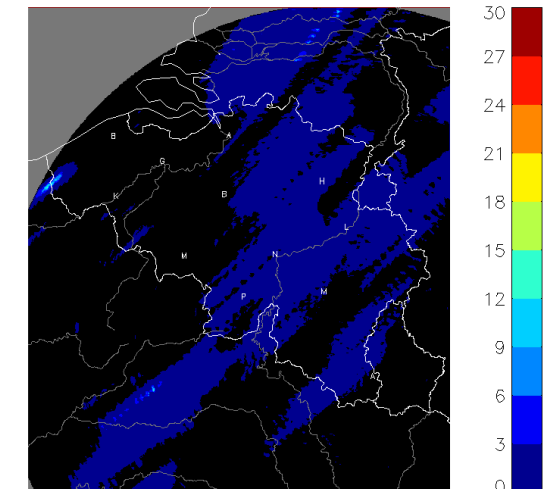
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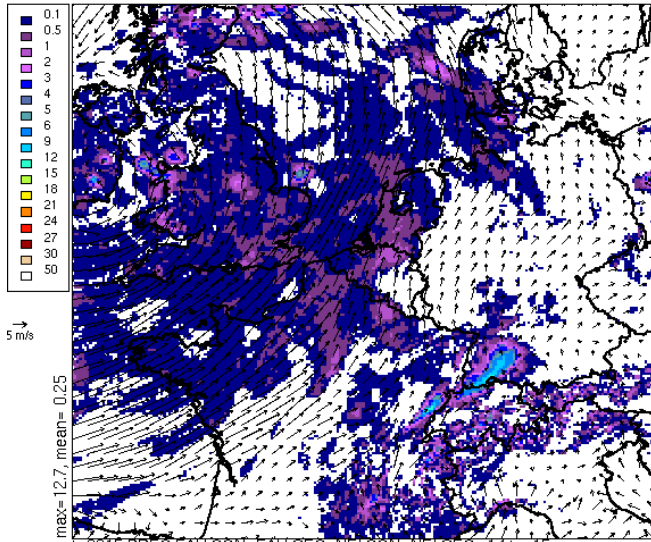


1h radar precipitation accumulation (mm) Starting at 01/10/2006 13 UT 12 /12 Radar Wideumont RMI - Belgium

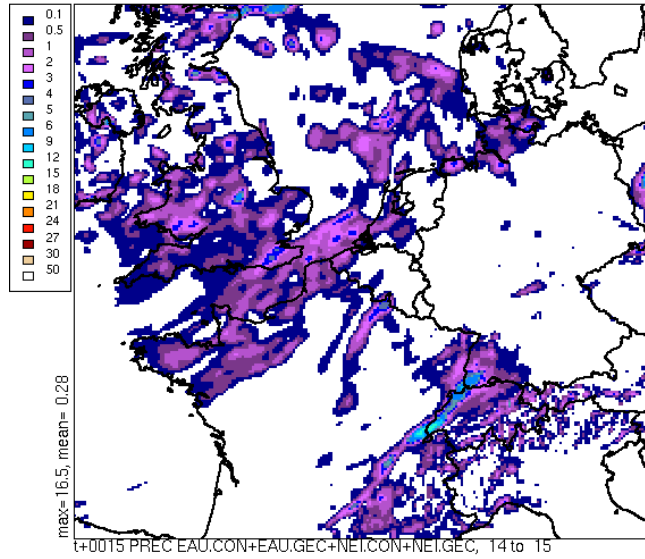


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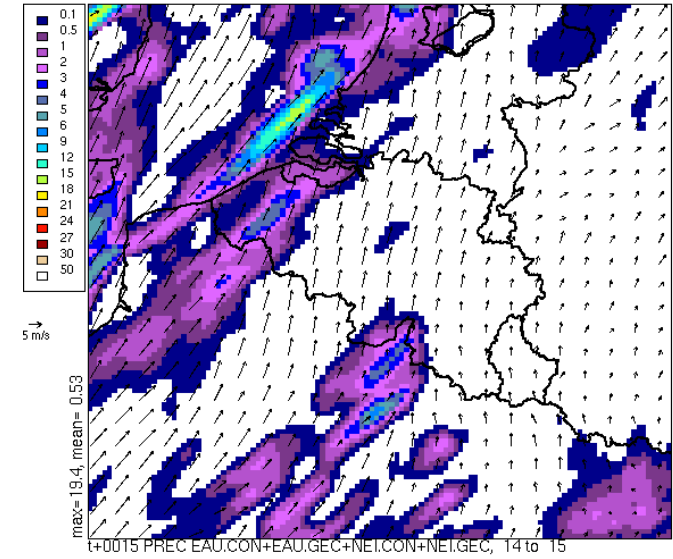
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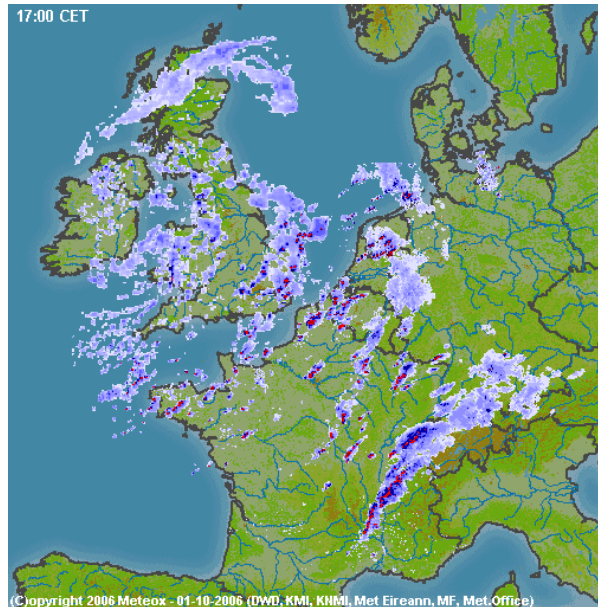
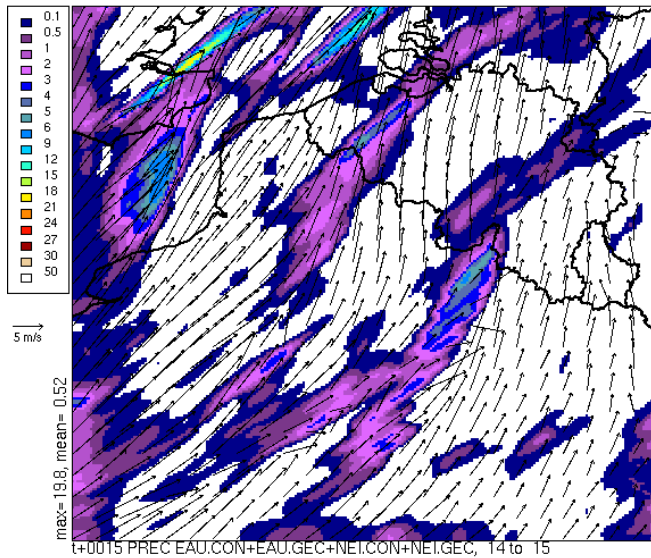
t7vl : 2006/10/1 z0:0 +15h



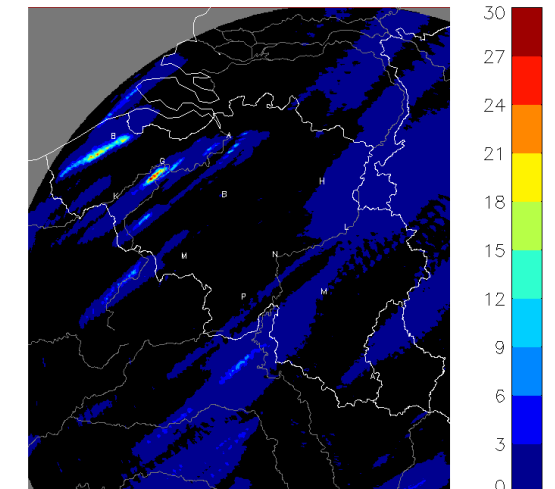
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t2vl : 2006/10/1 z0:0 +15h



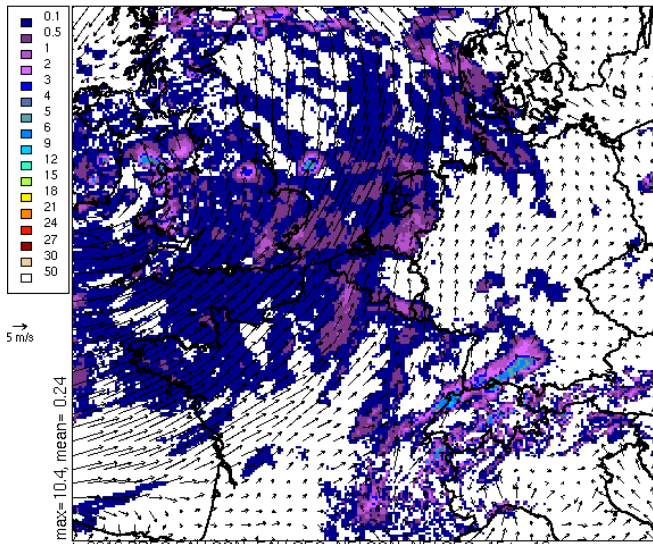
1h radar precipitation accumulation (mm) Starting at 01/10/2006 14 UT 12 /12 Radar Wideumont RMI - Belgium



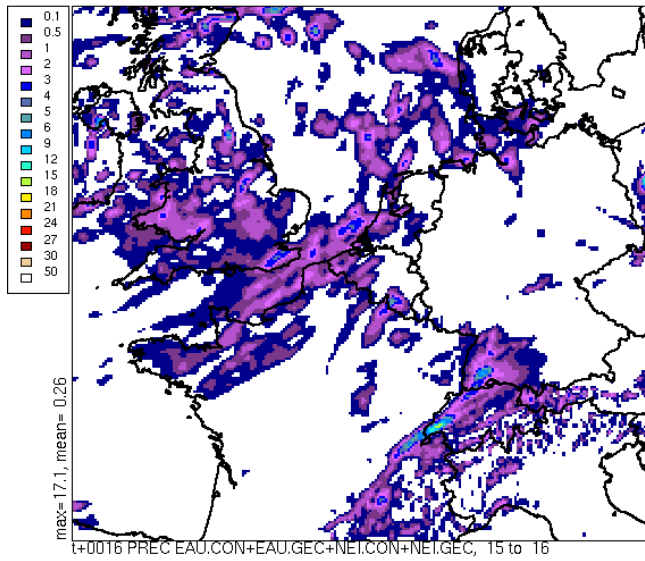


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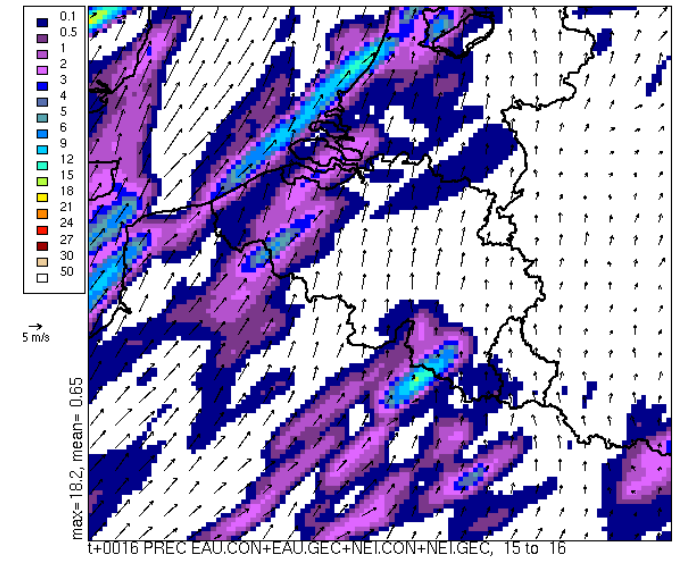
d7 : 2006/10/1 z0:0 +16h



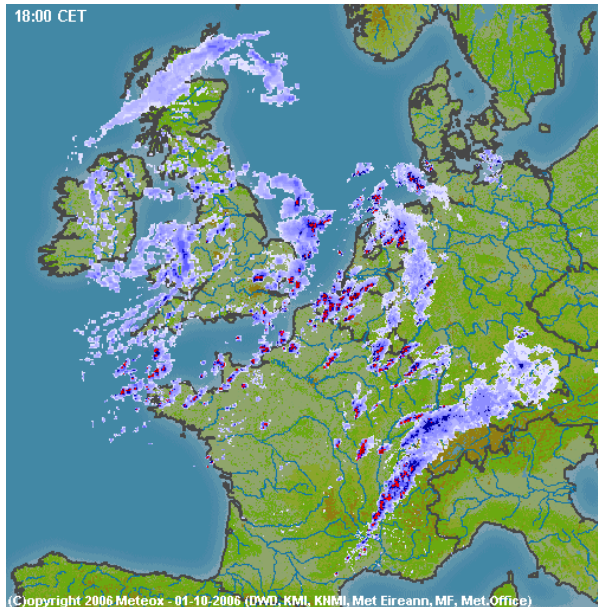
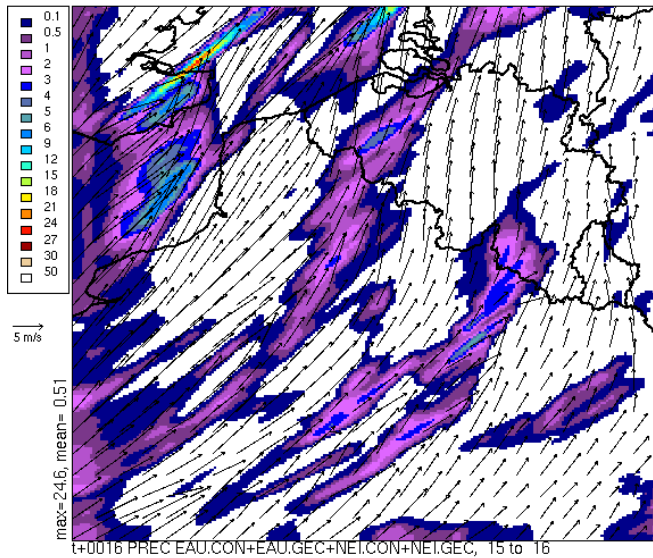
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t4vl : 2006/10/1 z0:0 +16h

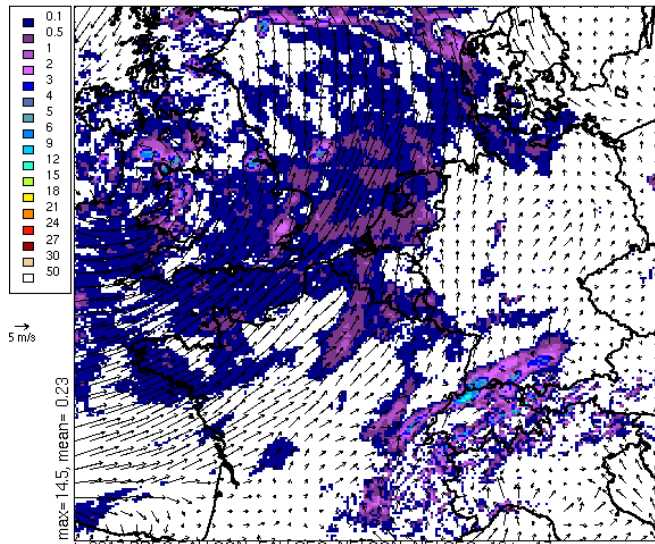


t2vl : 2006/10/1 z0:0 +16h

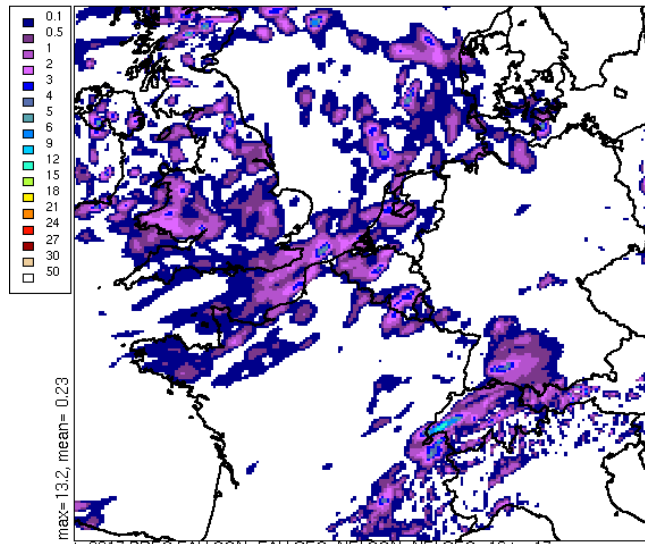


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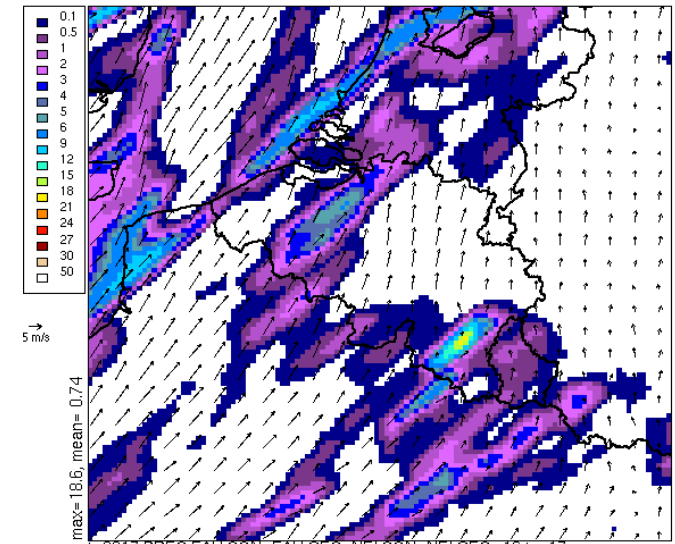
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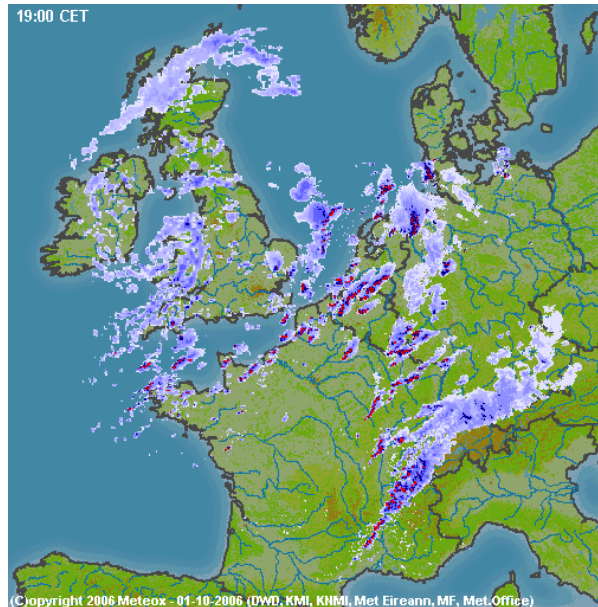
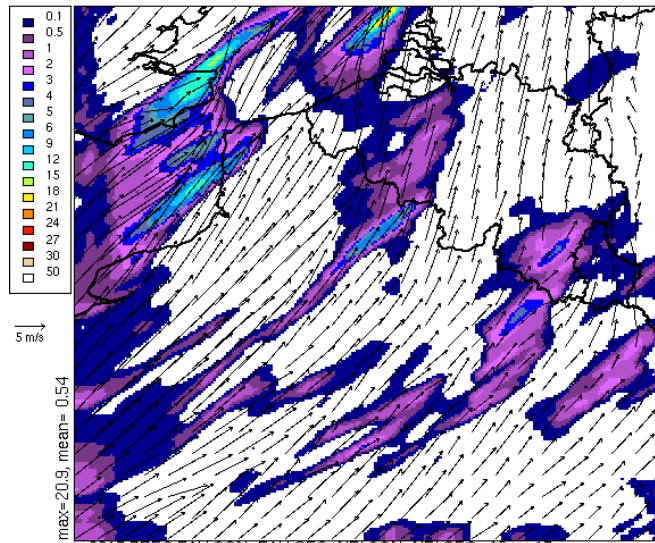
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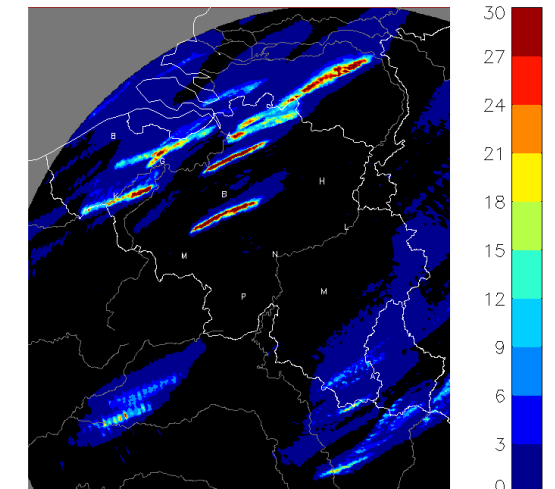
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t2vl : 2006/10/1 z0:0 +17h



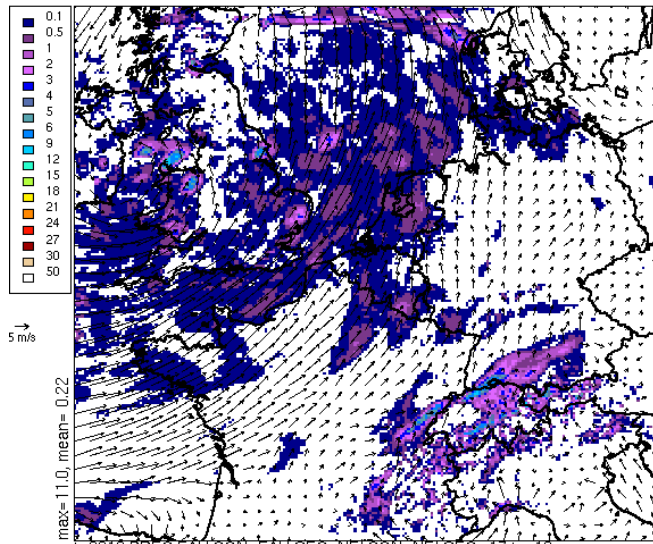
1h radar precipitation accumulation (mm) Starting at 01/10/2006 16 UT 12 /12 Radar Wideumont RMI - Belgium



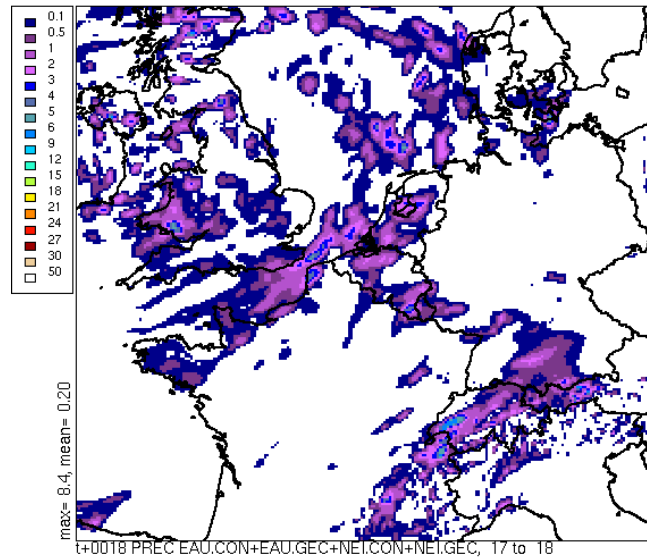


# Examples of prediction charts : squall lines 1/10/2006

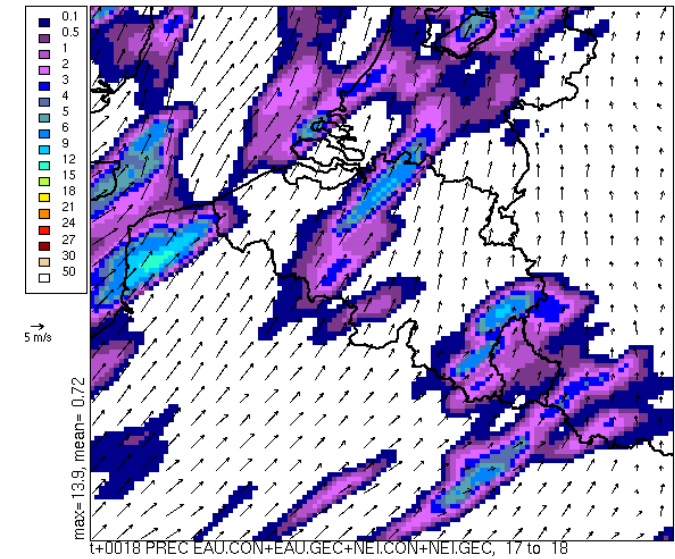
d7 : 2006/10/1 z0:0 +18h



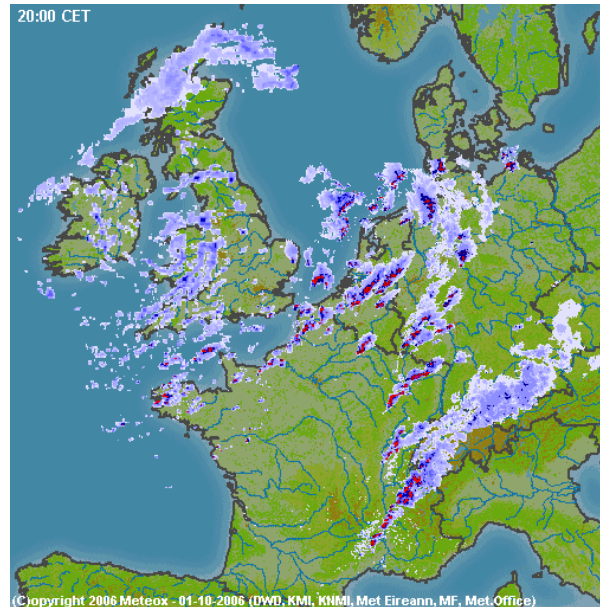
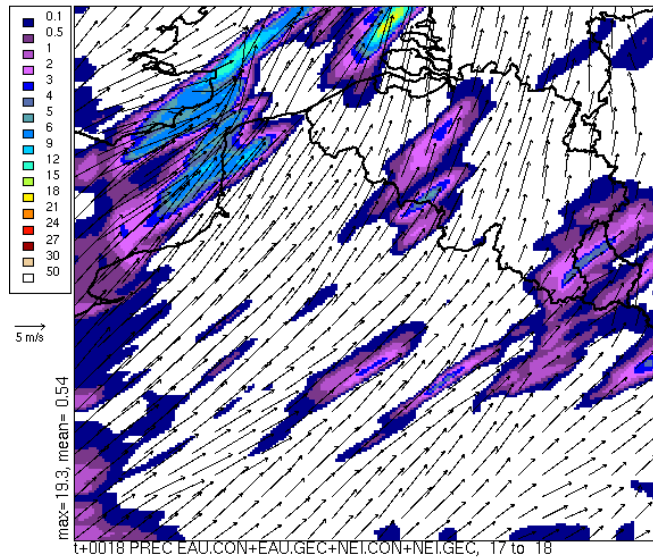
t7vl : 2006/10/1 z0:0 +18h



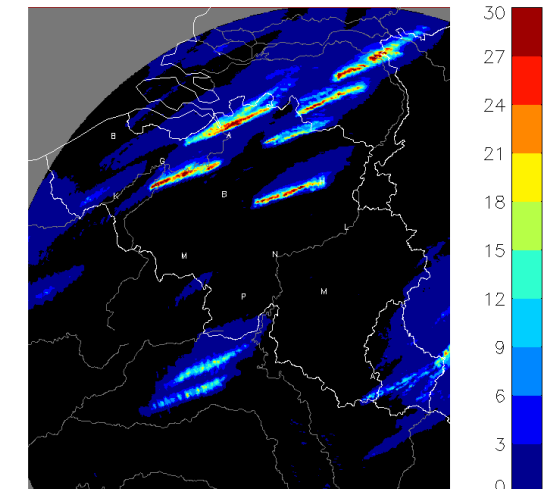
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t2vl : 2006/10/1 z0:0 +18h

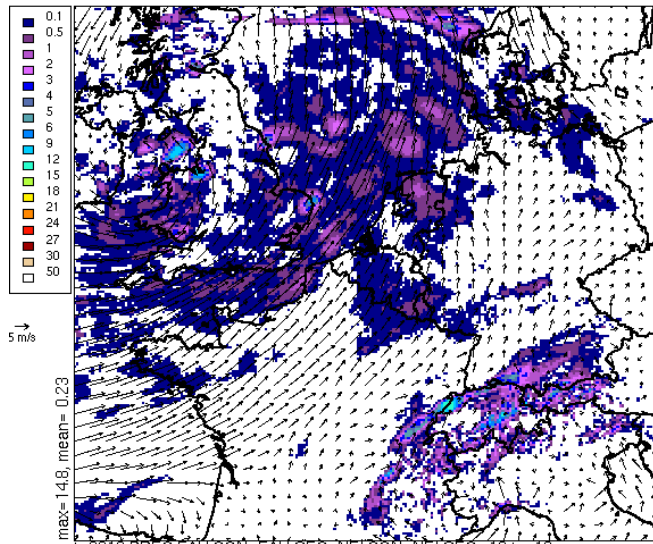


1h radar precipitation accumulation (mm) Starting at 01/10/2006 17 UT 12 /12 Radar Wideumont RMI - Belgium

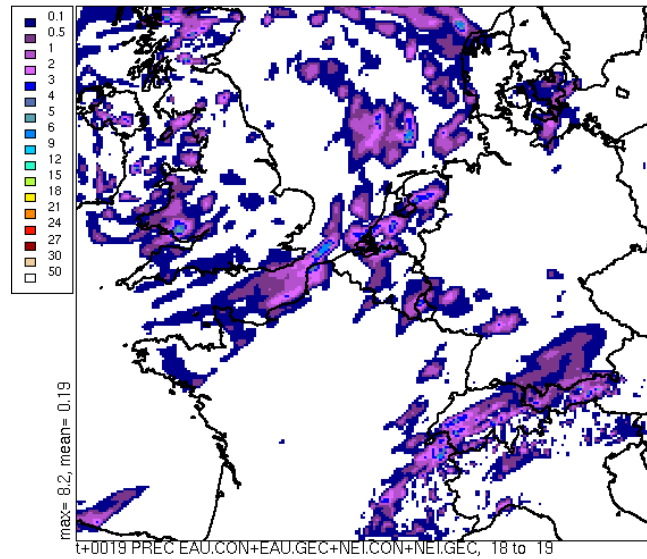


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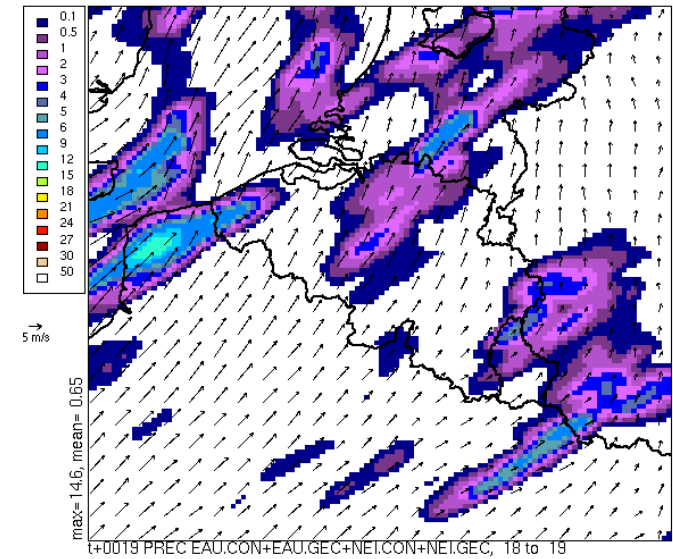
d7 : 2006/10/1 z0:0 +19h



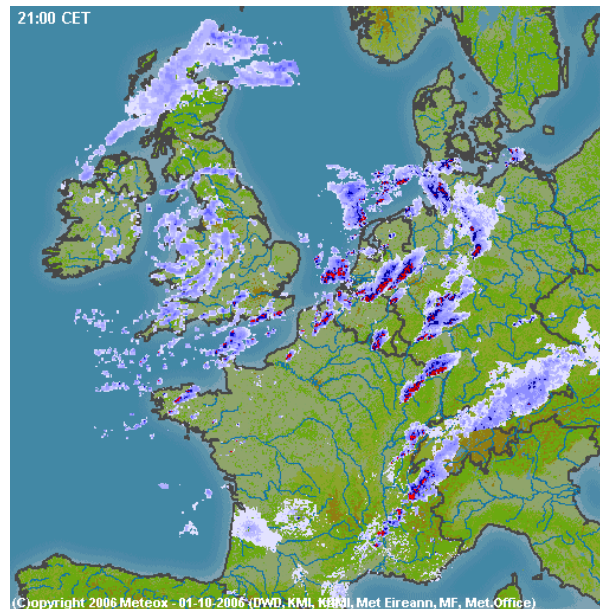
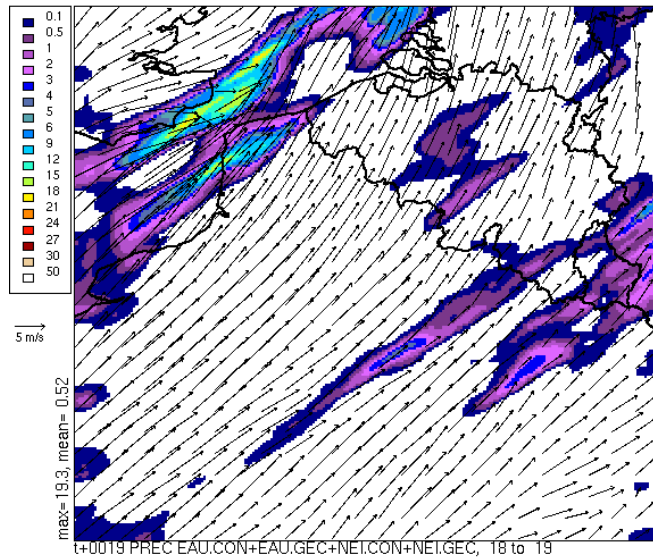
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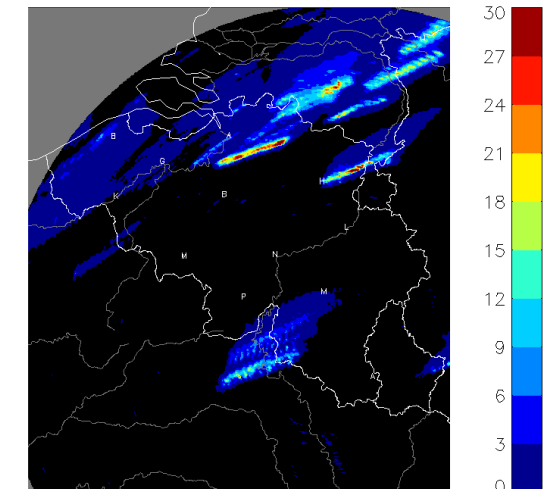
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t2vl : 2006/10/1 z0:0 +19h



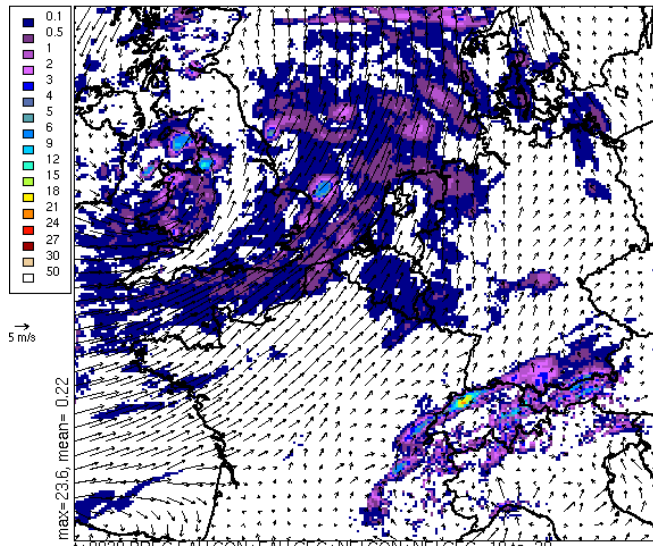
1h radar precipitation accumulation (mm) Radar Wideumont  
Starting at 01/10/2006 18 UT 12 /12 RMI - Belgium



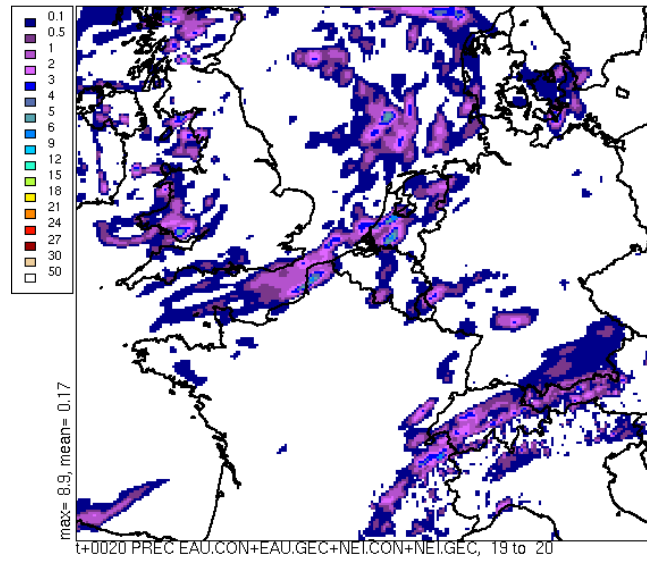


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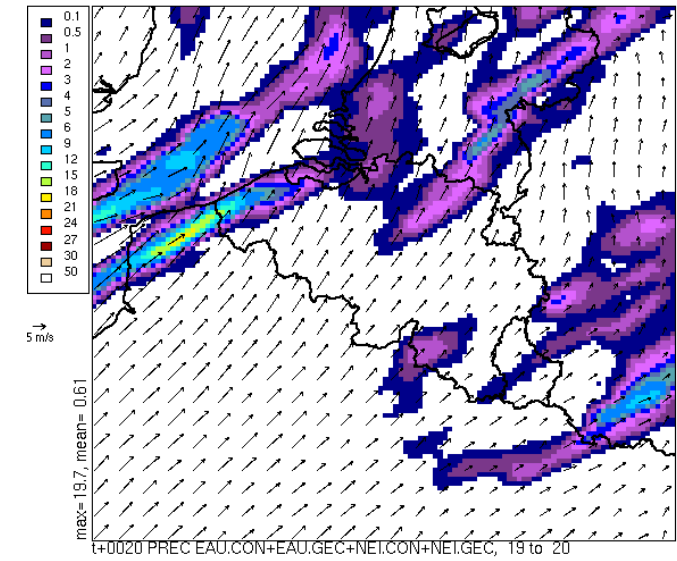
d7 : 2006/10/1 z0:0 +20h



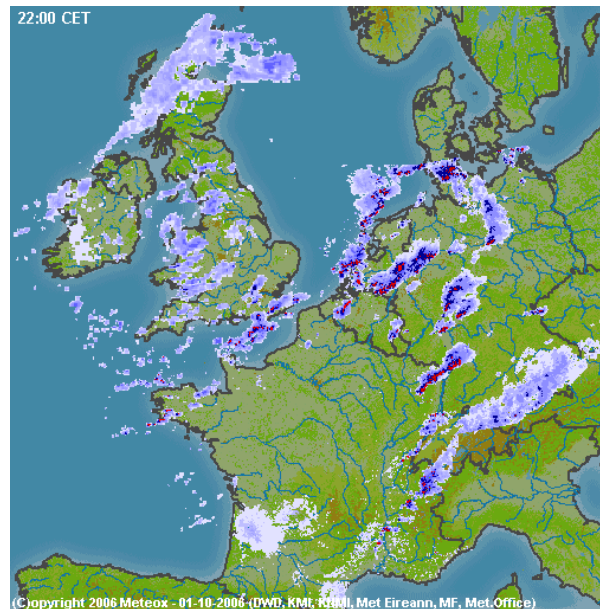
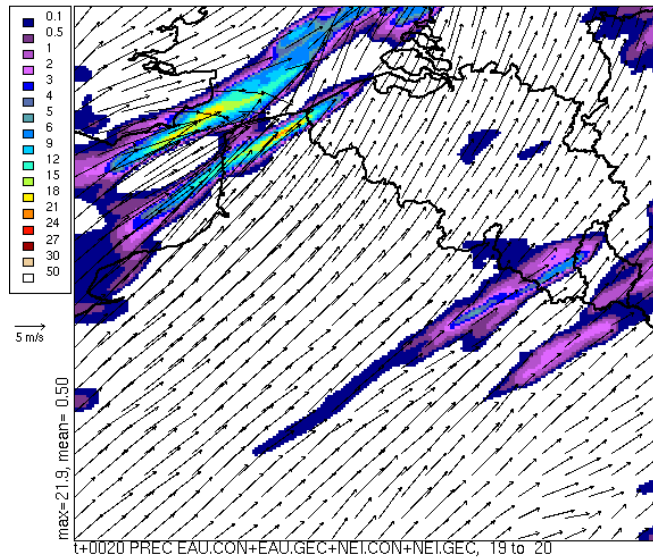
t7vl : 2006/10/1 z0:0 +20h



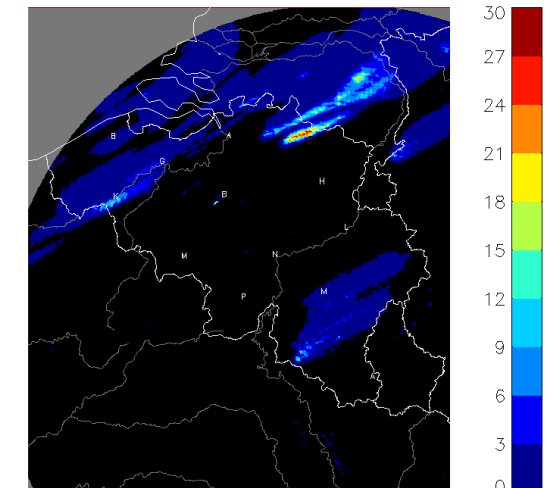
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t2vl : 2006/10/1 z0:0 +20h

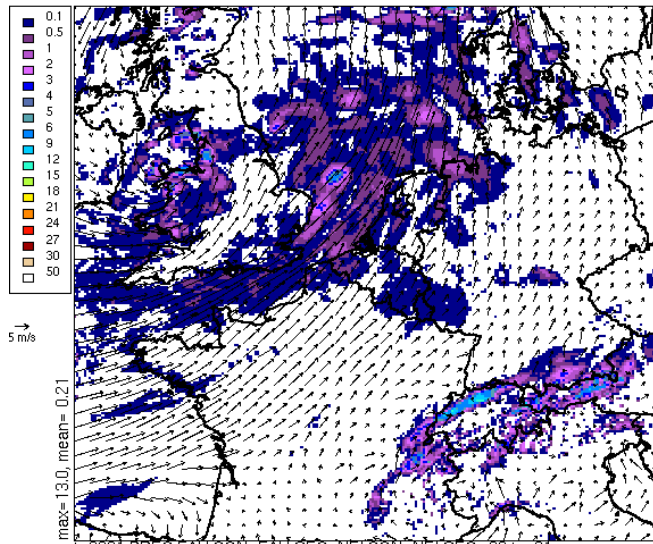


1h radar precipitation accumulation (mm) Starting at 01/10/2006 19 UT 12 /12

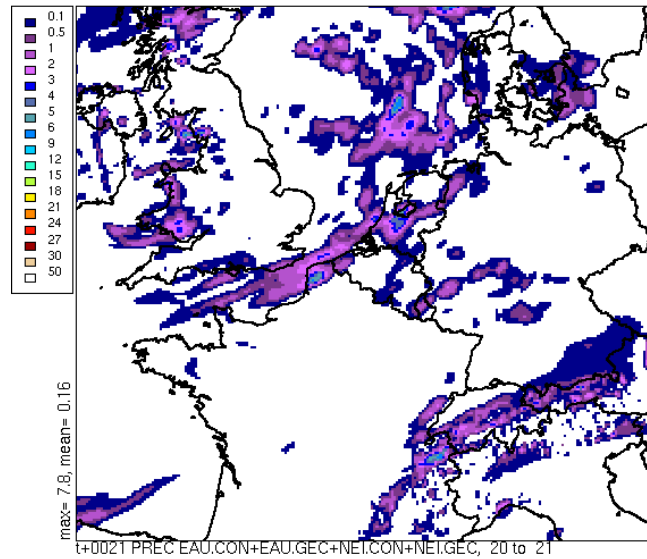


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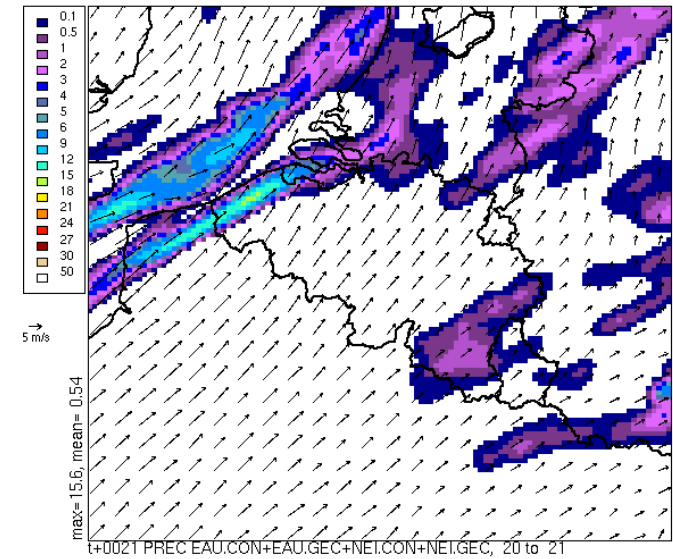
d7 : 2006/10/1 z0:0 +21h



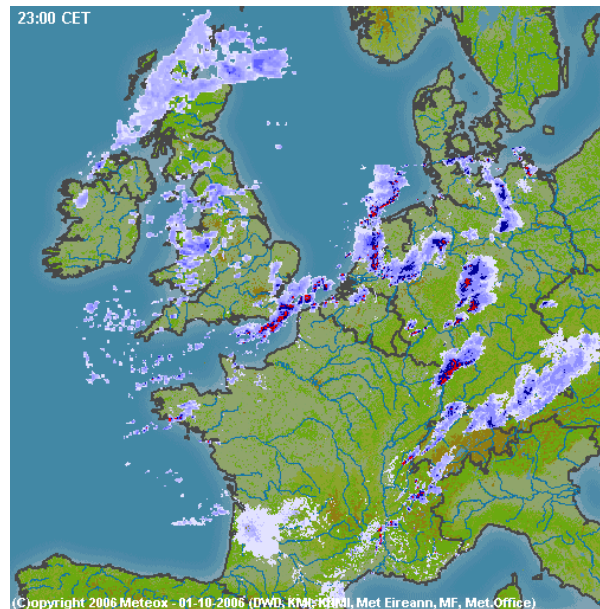
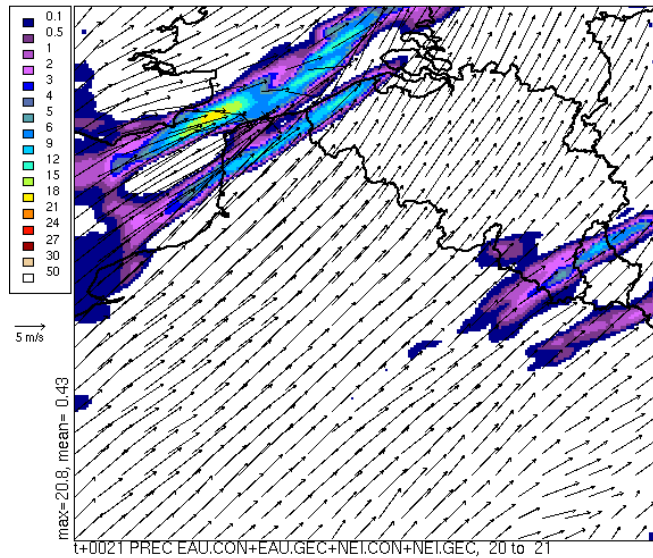
t7vl : 2006/10/1 z0:0 +21h



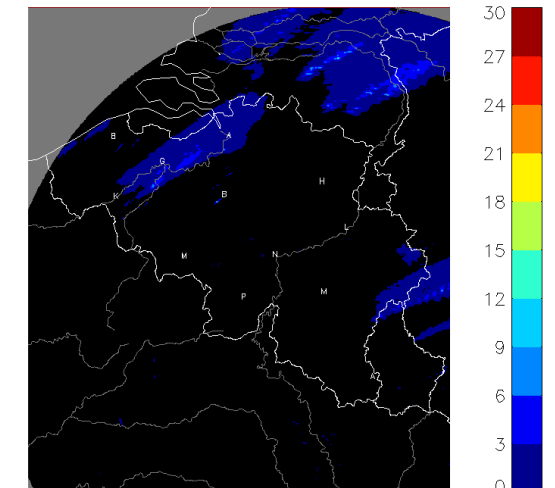
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t2vl : 2006/10/1 z0:0 +21h



1h radar precipitation accumulation (mm) Starting at 01/10/2006 20 UT 11 /12 Radar Wideumont RMI - Belgium



# Further work

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  - multi-scale tuning ;
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- Use of SURFEX