New approaches to deep convection parametrisation and its binding to a microphysical scheme

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IRM-KMI

Days's proposals

1. New facts
   - General context
   - Bad old habits
   - Back to basics by J.-M. Piriou
   - Choosing the right fluxes
   - How to share the moisture
   - New Microphysics and Convection scheme
2. Picture book : Surface charts, Cross sections.
3. Perspectives

Good old pans

– Resolved tendency

$$\frac{\partial\overline{\psi}}{\partial t} = -\overline{\mathbf{V}}\nabla\overline{\psi} - \overline{\omega}\frac{\partial\overline{\psi}}{\partial p} - \frac{\partial\overline{u'\psi'}}{\partial x} - \frac{\partial\overline{v'\psi'}}{\partial y} - \frac{\partial\overline{\omega'\psi'}}{\partial p} + S_\psi \qquad (1)$$

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– Mass flux approach :

$$\overline{\psi'\omega'} = \omega^{\overset{\wedge}{*}}\left(\psi_u - \overline{\psi}\right) + \omega^{\overset{\vee}{*}}\left(\psi_d - \overline{\psi}\right) \tag{3}$$

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more terms with significant mesh fractions !
approximations, additional hypotheses

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AARGHH !

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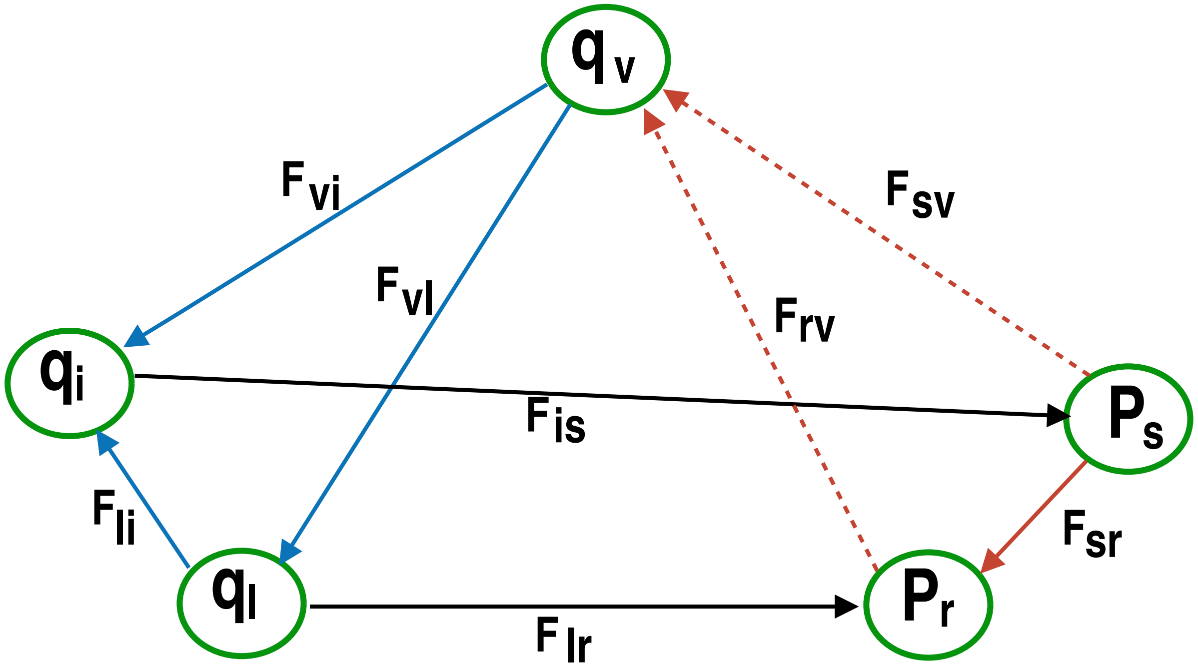
– Local budget

$$(\overset{\wedge}{\omega^*},\ E_u,\ \triangle q_{ca},\ q_{cu}) \longrightarrow \ \sigma_D \cdot q_{cD} \ \longrightarrow \ \sigma_D$$

Fluxes



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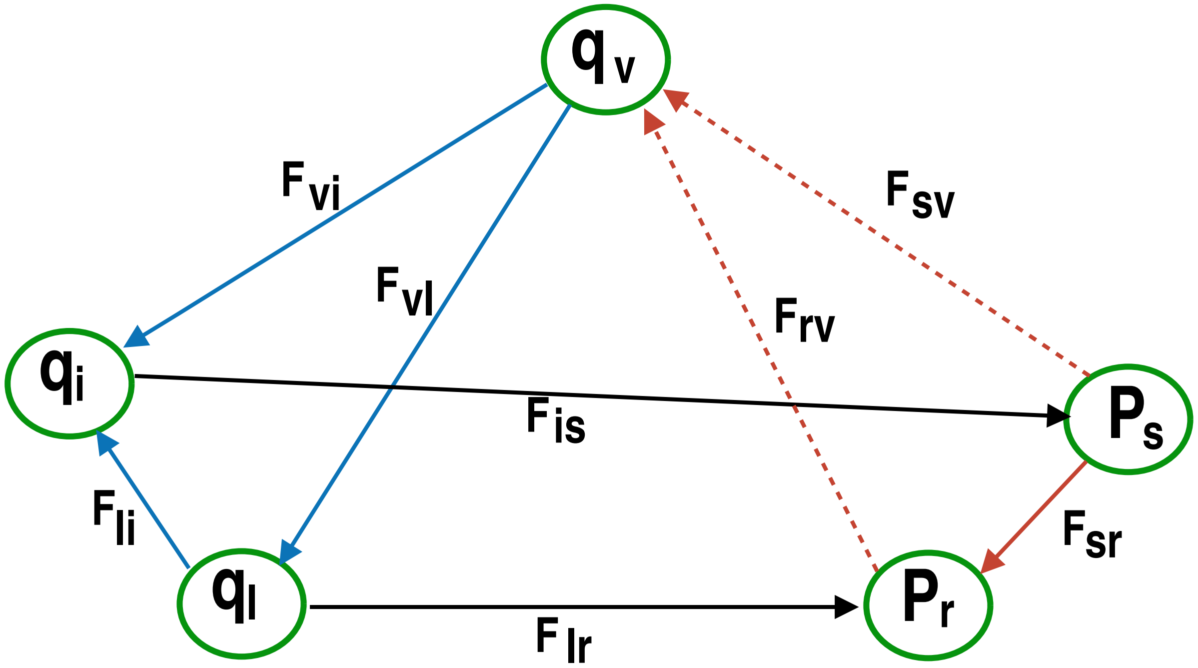

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$$F_{sv} = F_{is} - \mathcal{P}_s - F_{sr}$$

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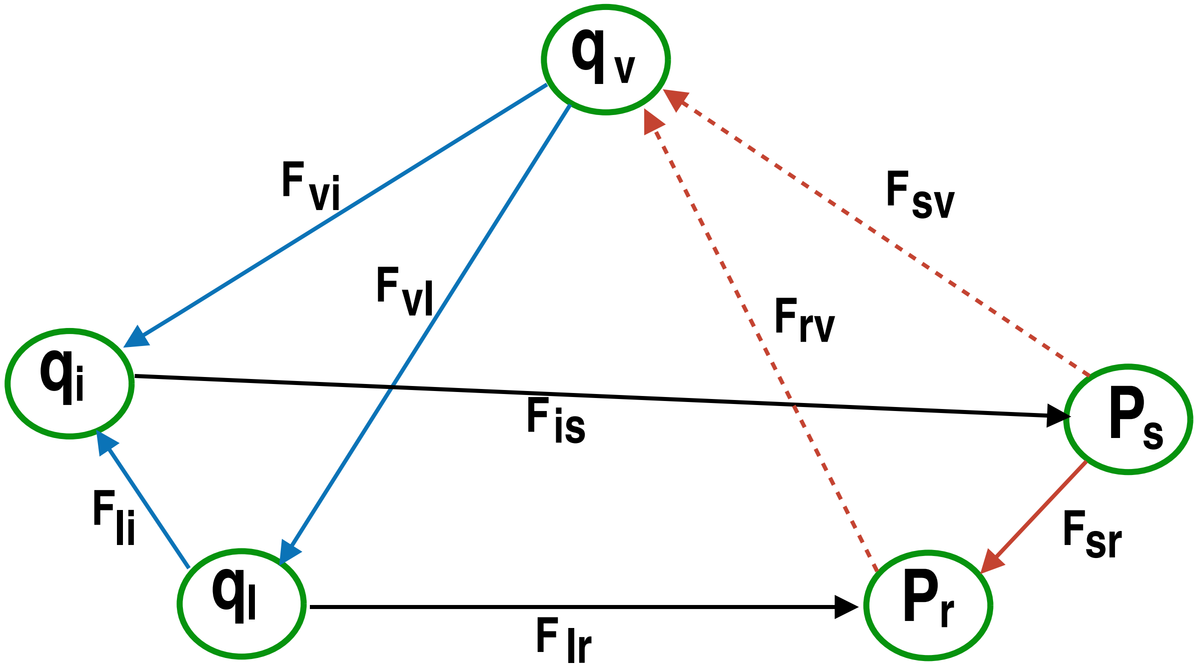

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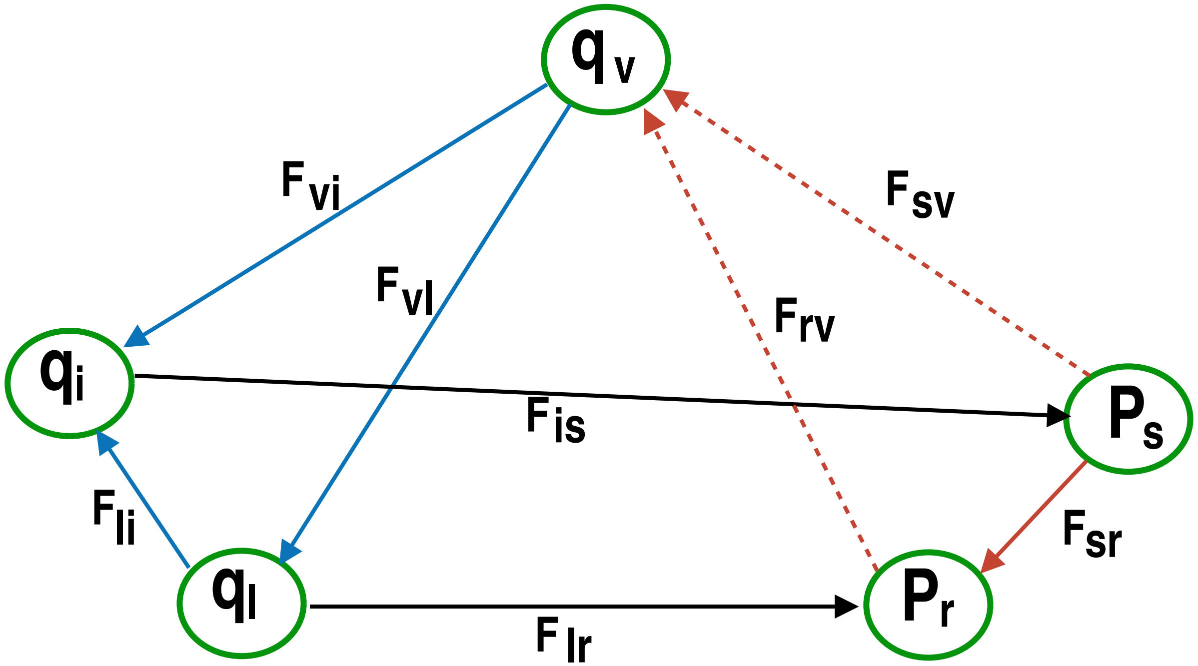

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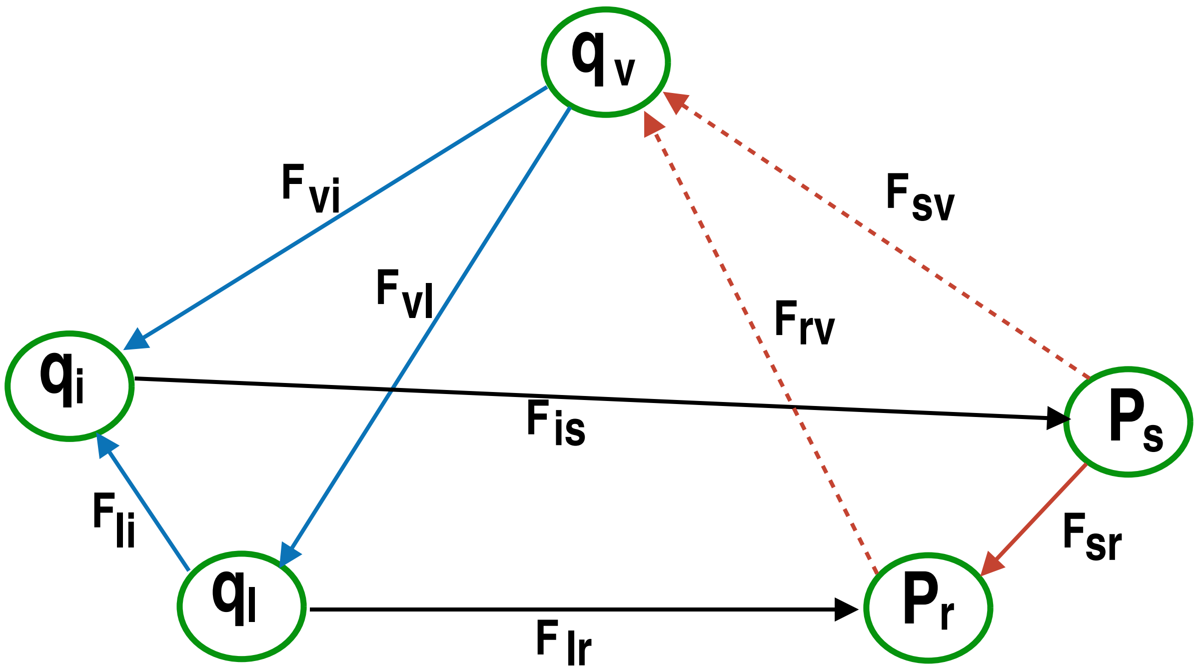

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$\mathcal{P}_s$ $\mathcal{P}_r$ and F_{vi} $F_{v\ell}$ $F_{\ell i}$ F_{is} $F_{\ell r}$

Old quarrels around the waterhole

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modulate ?

$$\Downarrow$$

$$\mathit{MOCON} \longrightarrow \boxed{\text{Deep Convection}} \rightarrow \mathcal{P}_{\mathrm{cu}}$$

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$$\overline{q_{v0}}\ ,\ \overline{q_{\ell 0}}\ ,\ \overline{q_{i0}}\ ,\ \overline{T_0} \qquad \text{and} \qquad f_{\mathrm{stra}}$$

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$$MOCON \longrightarrow \boxed{\text{Deep Convection}} \longrightarrow F^1_{vi},\ F^1_{v\ell},\ J^{\text{cu}}_v,\ J^{\text{cu}}_i,\ J^{\text{cu}}_\ell$$

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$$\boxed{\text{Autoconversion}}$$

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$$\overline{q_{t9}} = \overline{q_{v9}} + \overline{q_{\ell 9}} + \overline{q_{i9}}$$

$$\Downarrow \quad F^0_{\ell i},\ J^{\mathrm{td}}_i,\ J^{\mathrm{td}}_\ell$$

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The new cloud order

(Fix negative advected) $\longrightarrow J_\ell^{td},\ J_i^{td}$

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$f_{\rm stra} \longleftarrow$ Resolved condensation $\longrightarrow F_{vi},\ F_{v\ell}$

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$f^* \longleftarrow\ f_{\rm cu}^-,\ f_{\rm stra} \longleftarrow$ Resolved condensation $\longrightarrow F_{vi},\ F_{v\ell}$

$\downarrow$

$(n_L, n_M, n_H, n_T, n_C)$

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$f^* \longleftarrow\ f_{\rm cu}^-,\ f_{\rm stra} \longleftarrow$ **Resolved condensation** $\longrightarrow F_{vi},\ F_{v\ell}$

$\downarrow$

MOCON $\longrightarrow$ **Deep convection** $\longrightarrow F_{vi},\ F_{v\ell},\ J_\ell^{td},\ J_i^{td},$ $J_v^{cu},\ J_i^{cu},\ J_\ell^{cu},\ J_s^{cu},\ J_V^{cu}$

$\sigma_D \longleftarrow$ **Deep convection**

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$f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ Deep convection

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(Phase adjust) $\longrightarrow F_{\ell i}$

$f^* \longleftarrow\ f_{\rm cu}^-,\ f_{\rm stra} \longleftarrow$ **[Resolved condensation]** $\longrightarrow F_{vi},\ F_{v\ell}$

$\downarrow$

MOCON $\longrightarrow$

$f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ **[Deep convection]** $\longrightarrow F_{vi},\ F_{v\ell},\ J_\ell^{td},\ J_i^{td},\ J_v^{cu},\ J_i^{cu},\ J_\ell^{cu},\ J_s^{cu},\ J_V^{cu}$

$(n_L, n_M, n_H, n_T, n_C)$ **[Aucoconversion]** $\longrightarrow F_{is},\ F_{\ell r},\ F_{\ell i}$

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$f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ **Deep convection**

$(n_L, n_M, n_H, n_T, n_C)$ — **Aucoconversion** $\longrightarrow F_{is},\ F_{\ell r},\ F_{\ell i}$

Precipitation $\longrightarrow \mathcal{P}_r,\ \mathcal{P}_s,\ F_{\ell i}, \alpha_{\rm snow}$

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$\downarrow$

$f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ **Deep convection**

$(n_L, n_M, n_H, n_T, n_C)$

Aucoconversion $\longrightarrow F_{is},\ F_{\ell r},\ F_{\ell i}$

Precipitation $\longrightarrow \mathcal{P}_r,\ \mathcal{P}_s,\ F_{\ell i}, \alpha_{\rm snow}$

(Phase adjust) $\longrightarrow F_{\ell i}$

Downdraught $\longrightarrow \mathcal{P}_r,\ \mathcal{P}_s,\ J_\ell^{td},\ J_i^{td},\ J_v^{cu},\ J_i^{cu},\ J_\ell^{cu},\ J_s^{cu},\ J_V^{cu}$

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$f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ Deep convection

$(n_L, n_M, n_H, n_T, n_C)$ **Aucoconversion** $\longrightarrow F_{is},\ F_{\ell r},\ F_{\ell i}$

Precipitation $\longrightarrow \mathcal{P}_r,\ \mathcal{P}_s,\ F_{\ell i}, \alpha_{\rm snow}$

(Phase adjust) $\longrightarrow F_{\ell i}$

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$\sigma_D \leftrightarrow f\ \longrightarrow$ (Convective/Resolved) $\longrightarrow \mathcal{P}_r^{cu},\ \mathcal{P}_s^{cu},\ \mathcal{P}_r^{ls},\ \mathcal{P}_s^{ls}$

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$\downarrow$ $\quad f \leftarrow f_{\rm stra},\ \sigma_D \longleftarrow$ Deep convection

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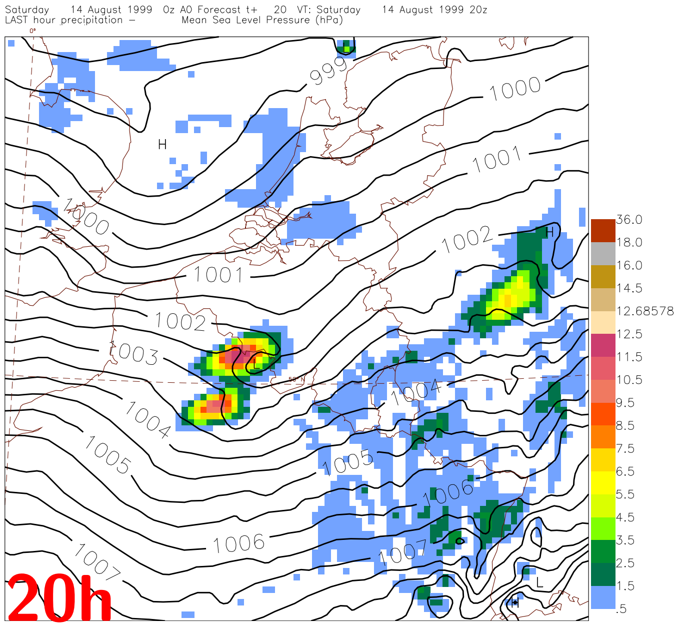
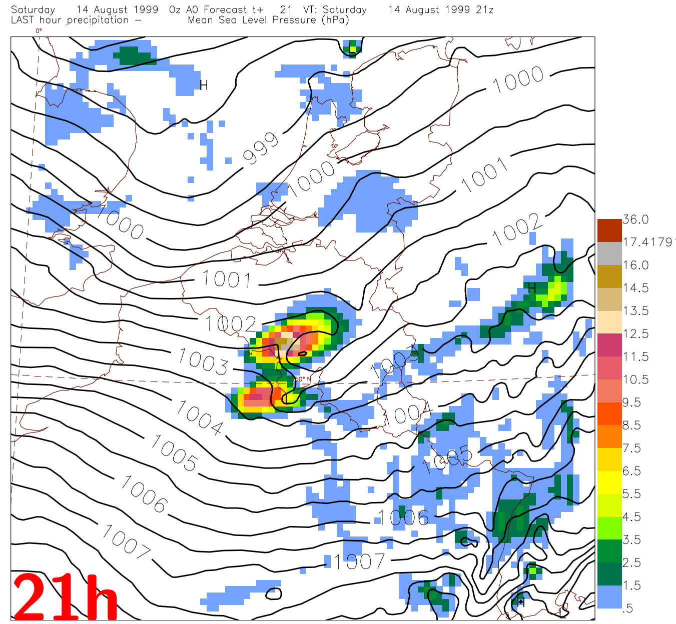
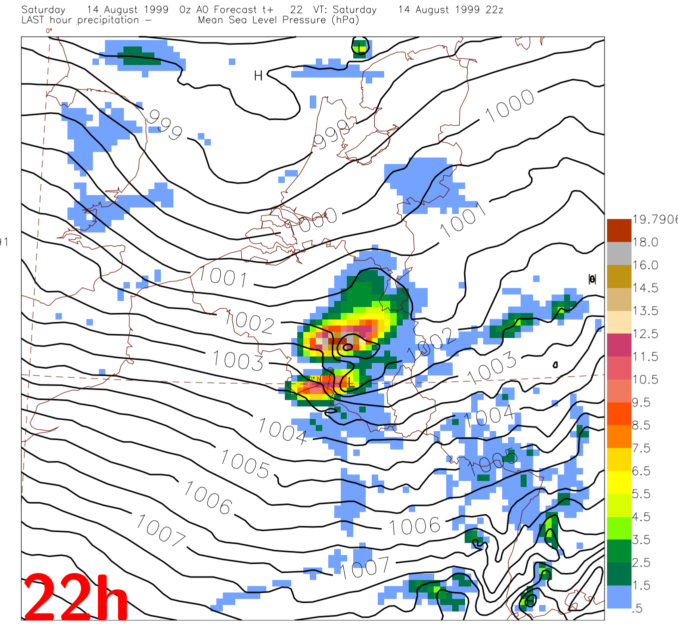
$f_{cu} \longleftarrow\ \ \sigma_D \leftrightarrow f \longrightarrow$ (Convective/Resolved) $\longrightarrow \mathcal{P}_r^{cu},\ \mathcal{P}_s^{cu},\ \mathcal{P}_r^{ls},\ \mathcal{P}_s^{ls}$

The Tournai case

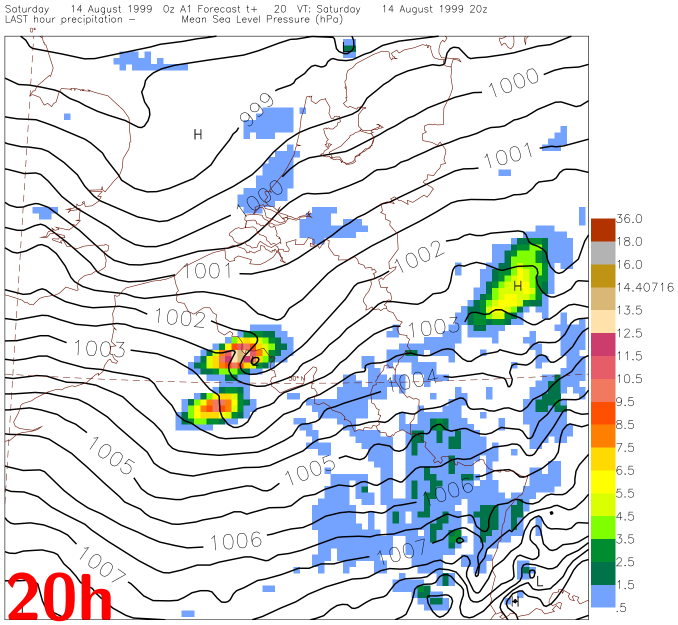
Diagnostic

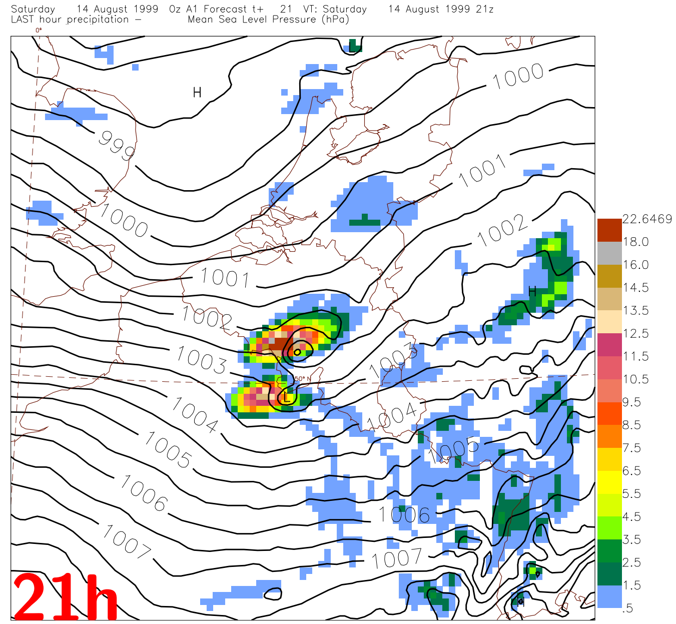


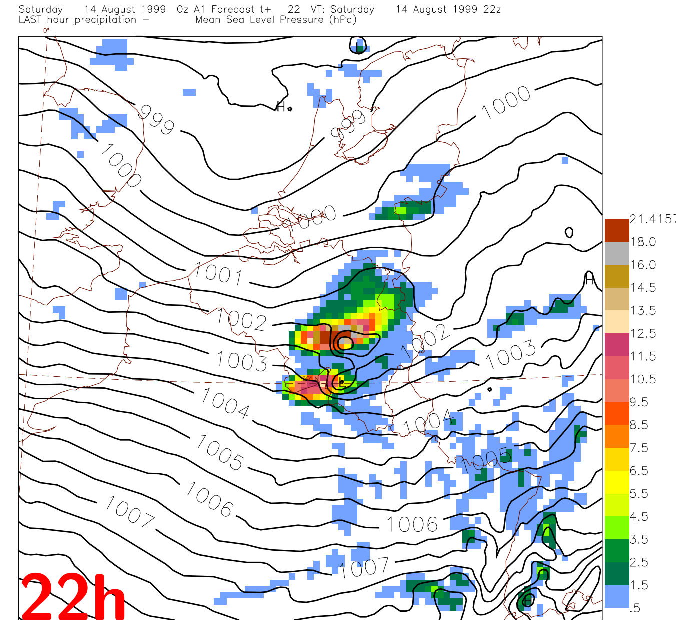




Prognostic

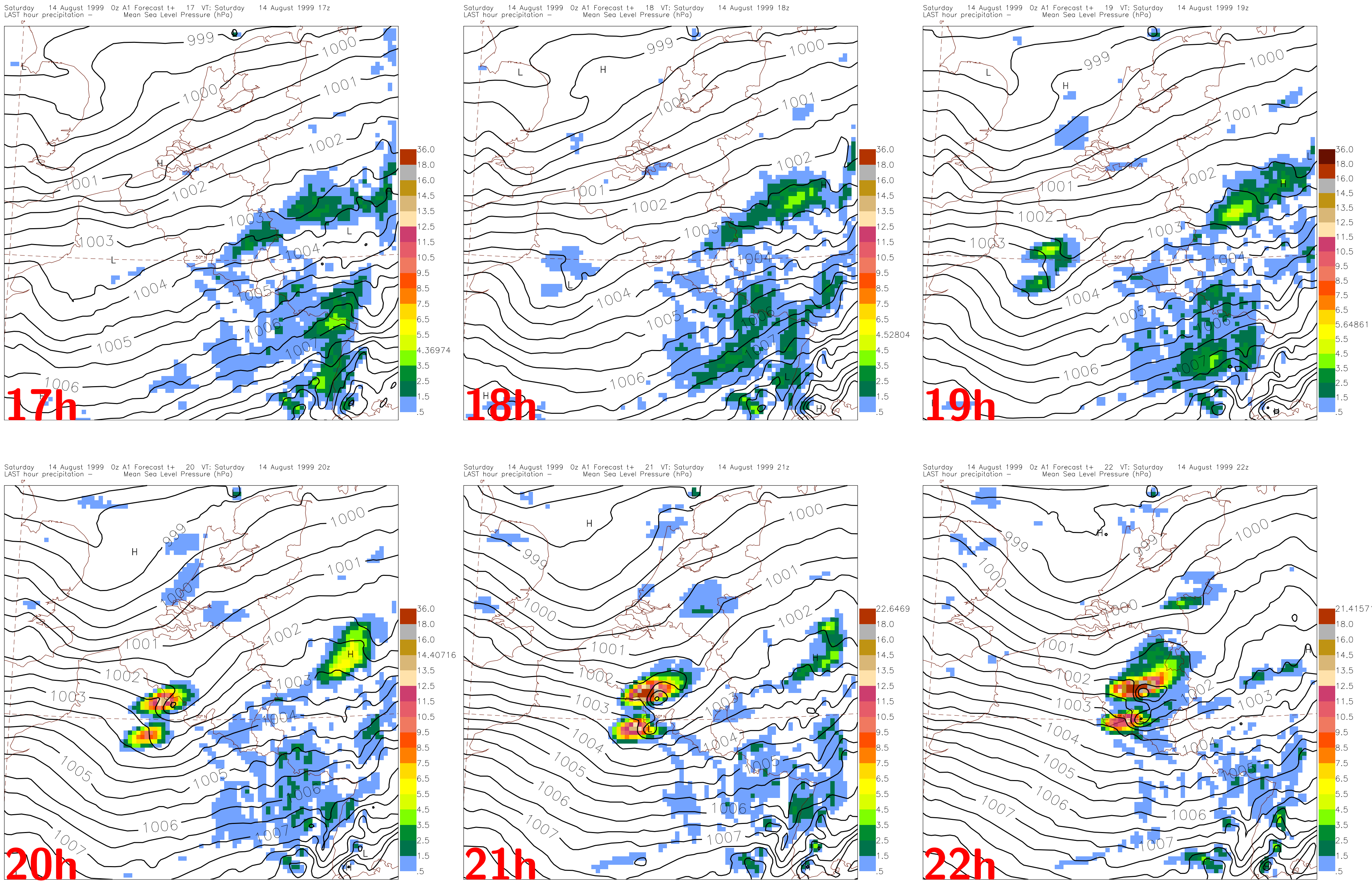






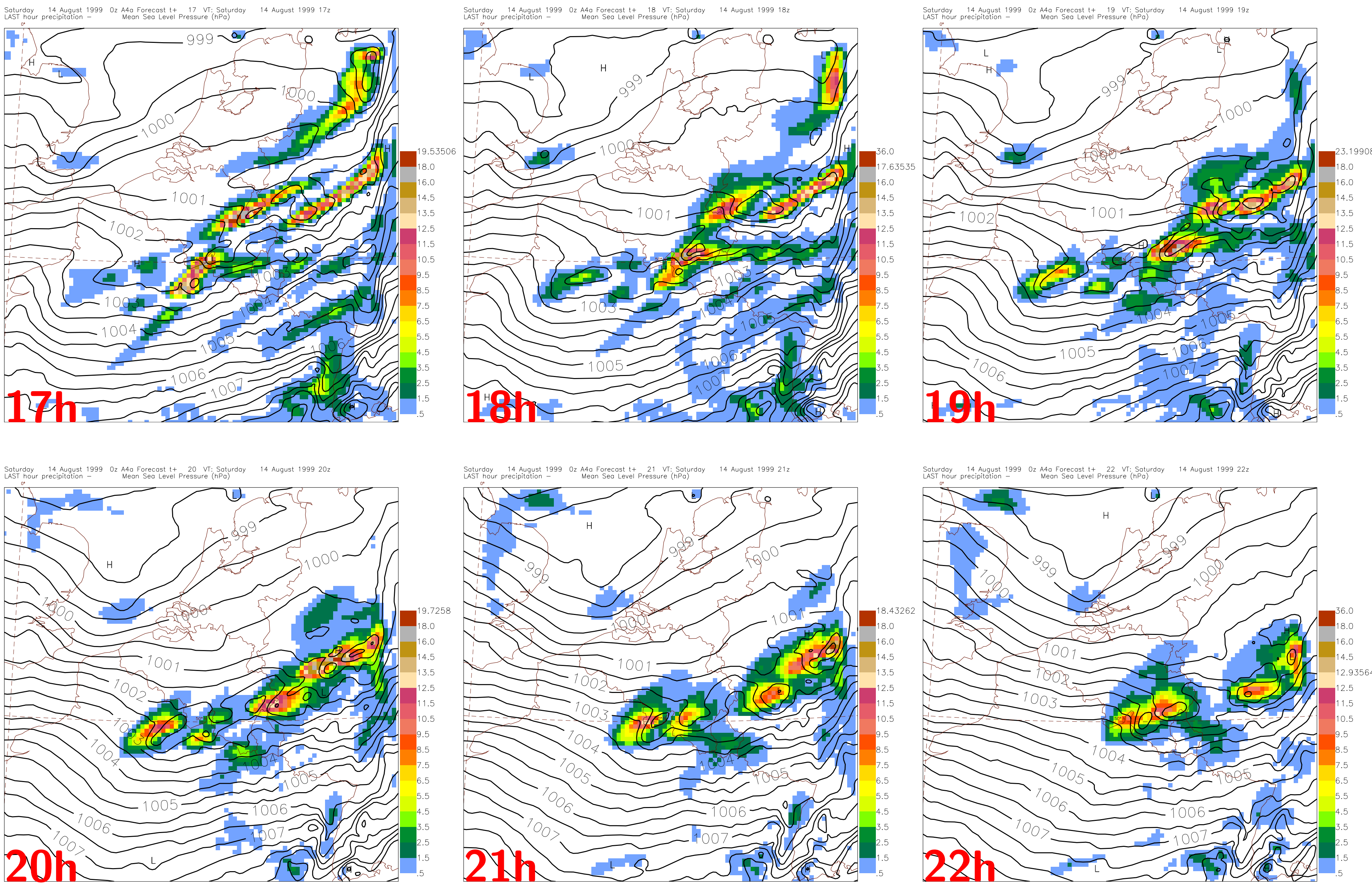
The Tournai case

Prognostic convection



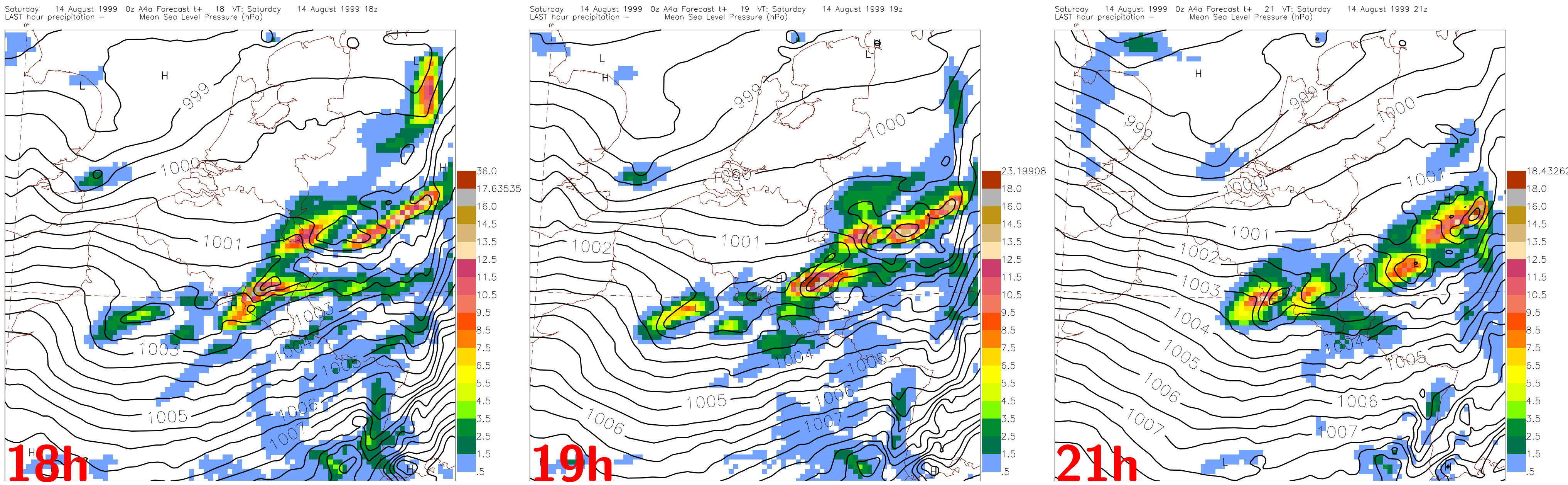
Integrated Microphysics And Convection

The Tournai case

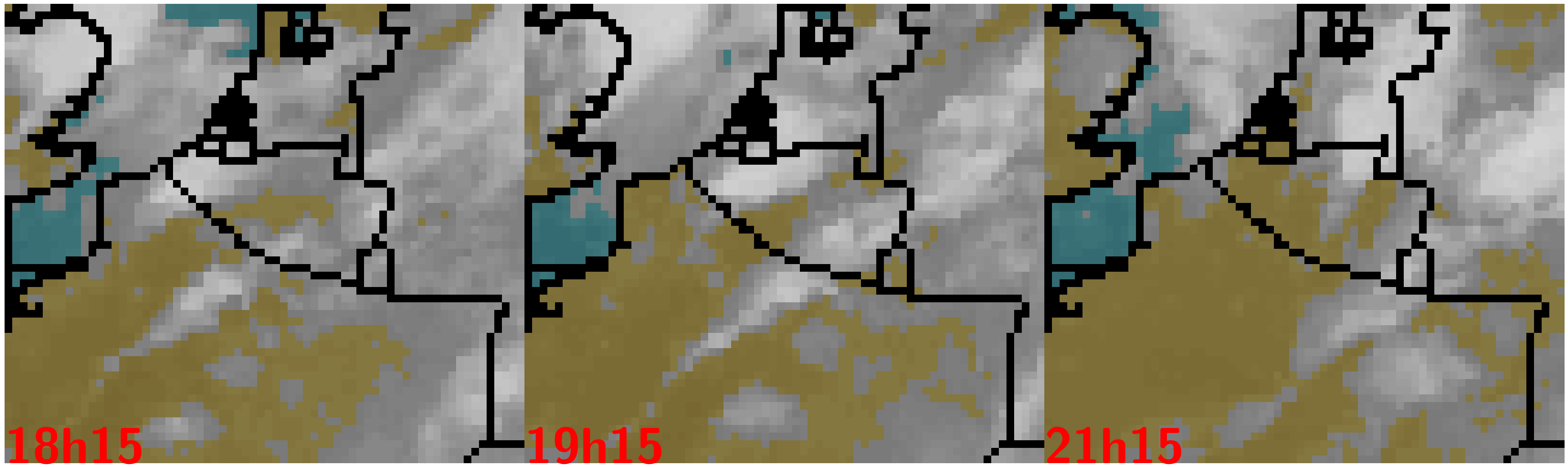


The Tournai case

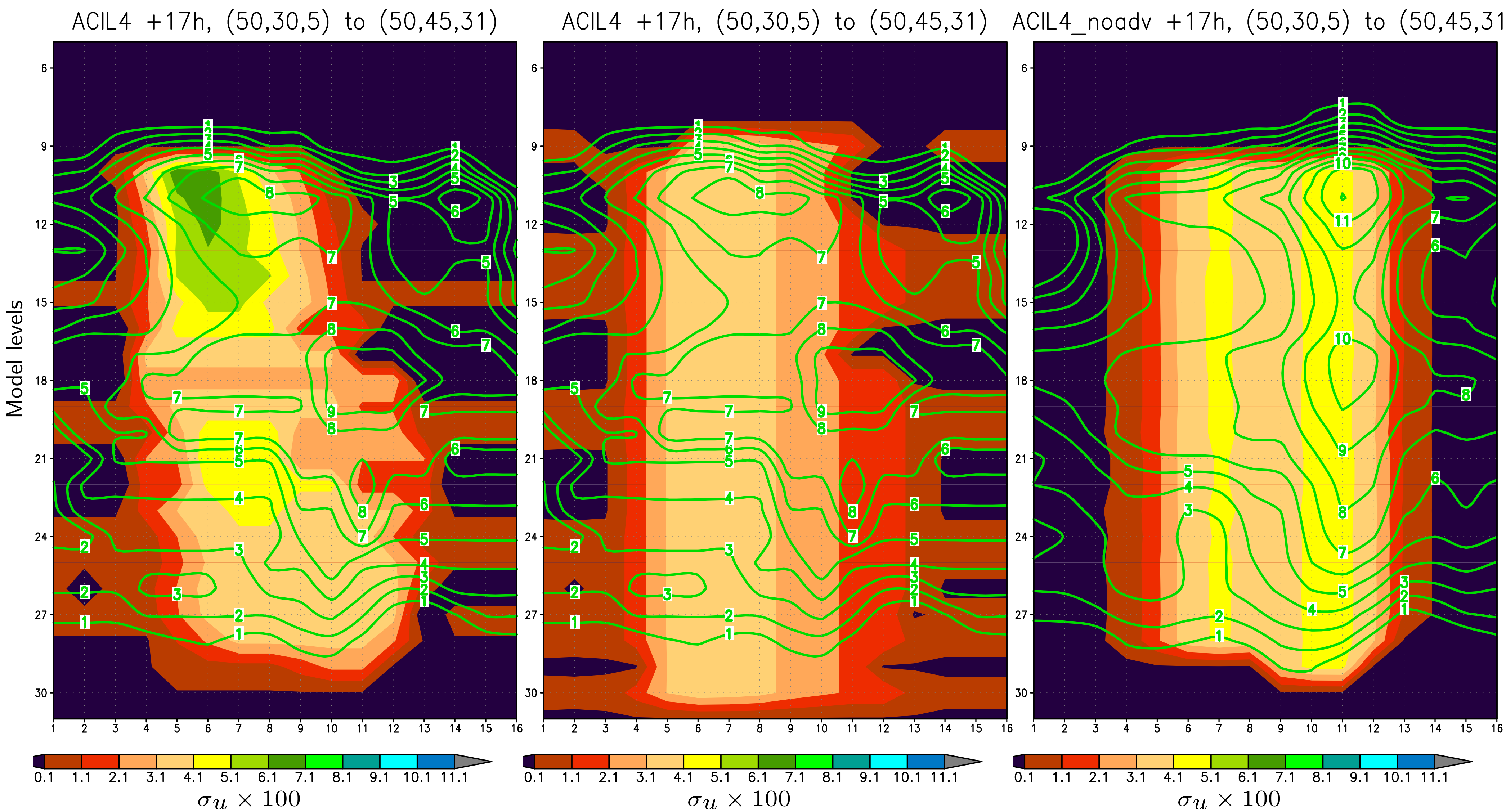
I.M.A.C.



Meteosat IR



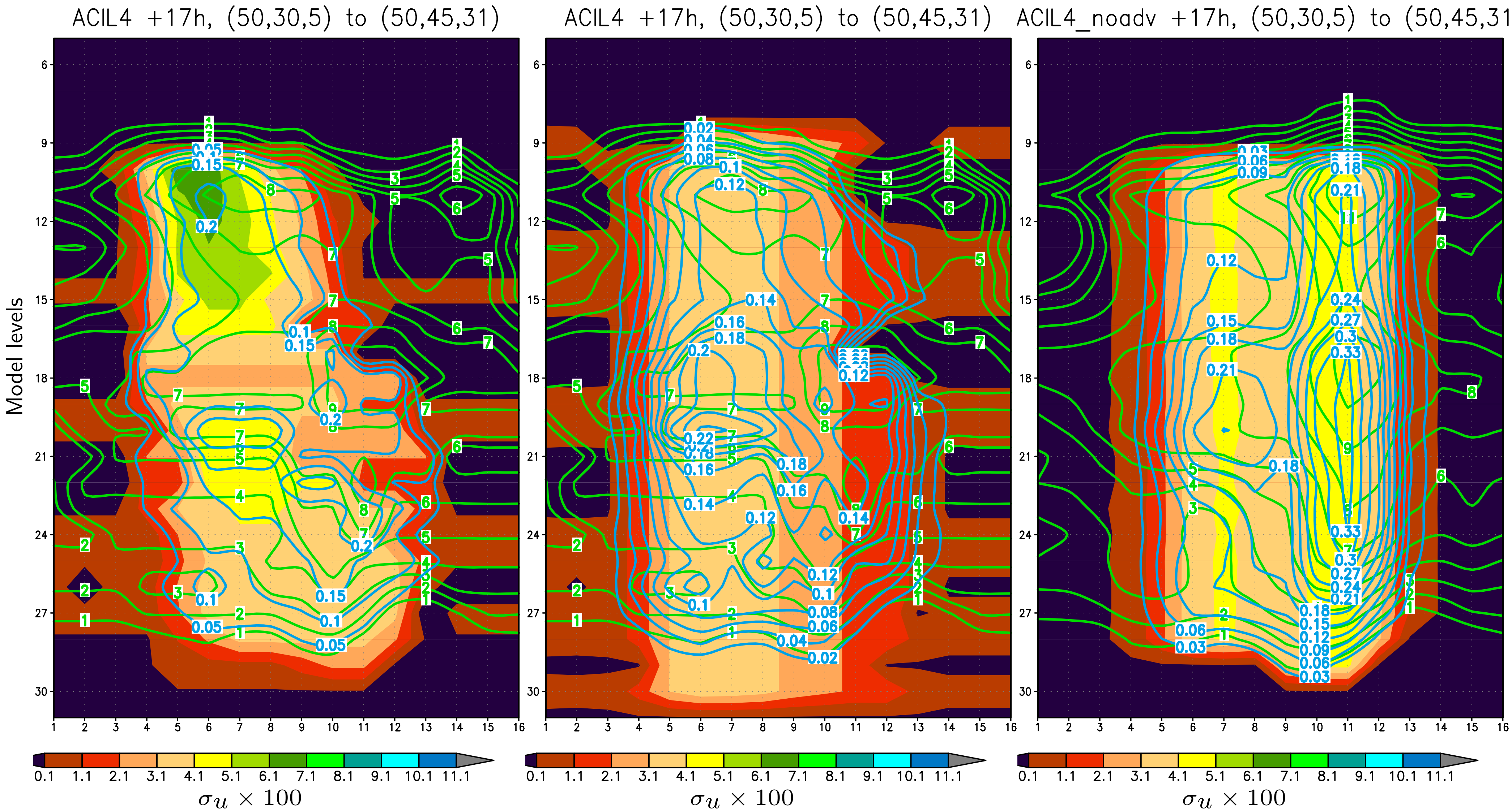
The Tournai case



w_u, advected σ_u | w_u, averaged σ_u | w_u, σ_u, no advection

updraught vertical cross sections

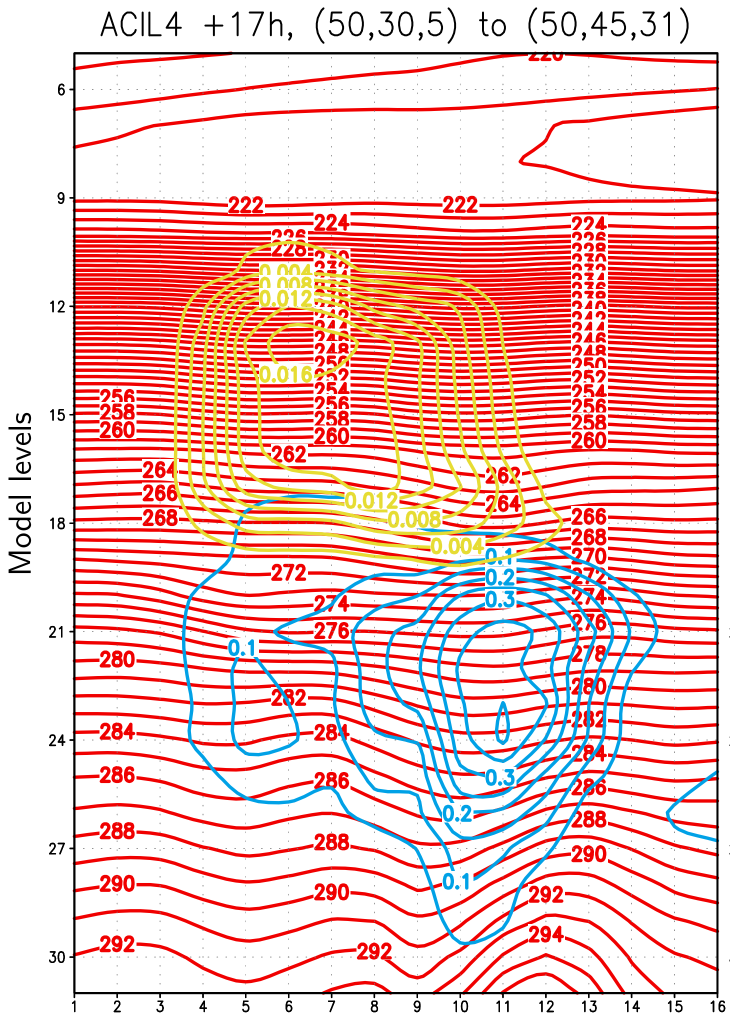
The Tournai case



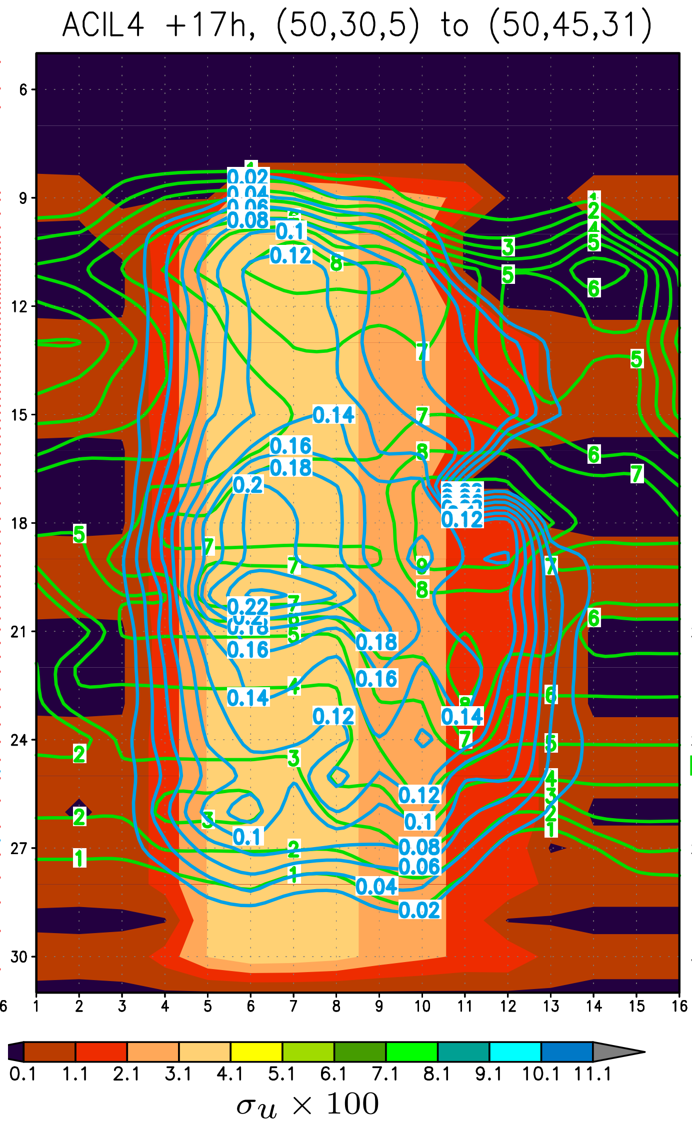
w_u, advected σ_u, M_u | w_u, averaged σ_u, M_u | w_u, σ_u, M_u, no advection

updraught vertical cross sections

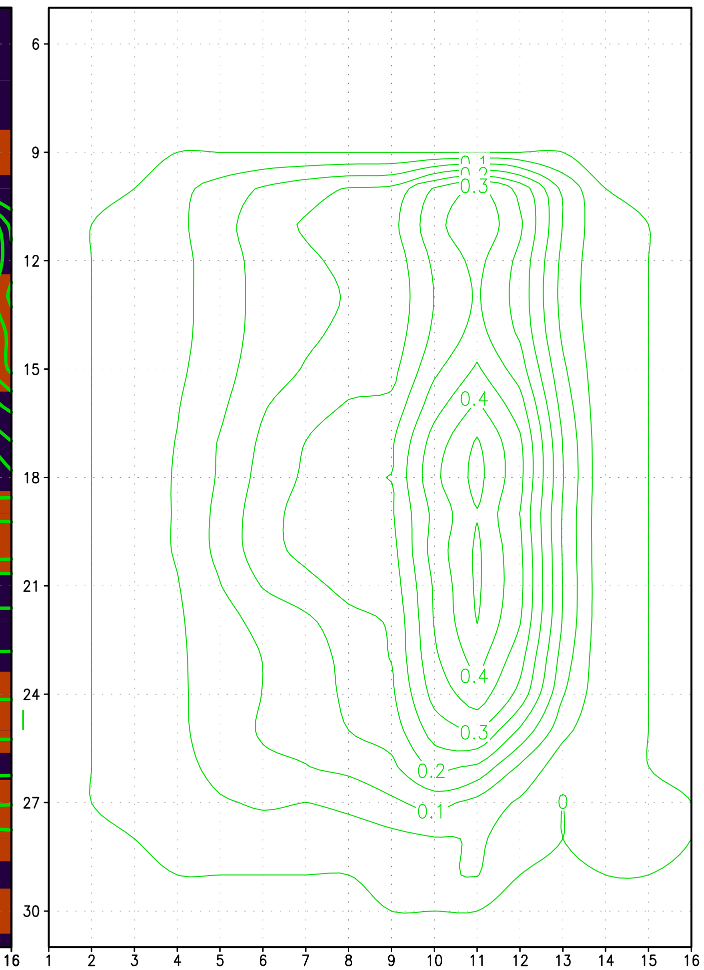
The Tournai case



T [K] q_ℓ, q_i [g/kg]



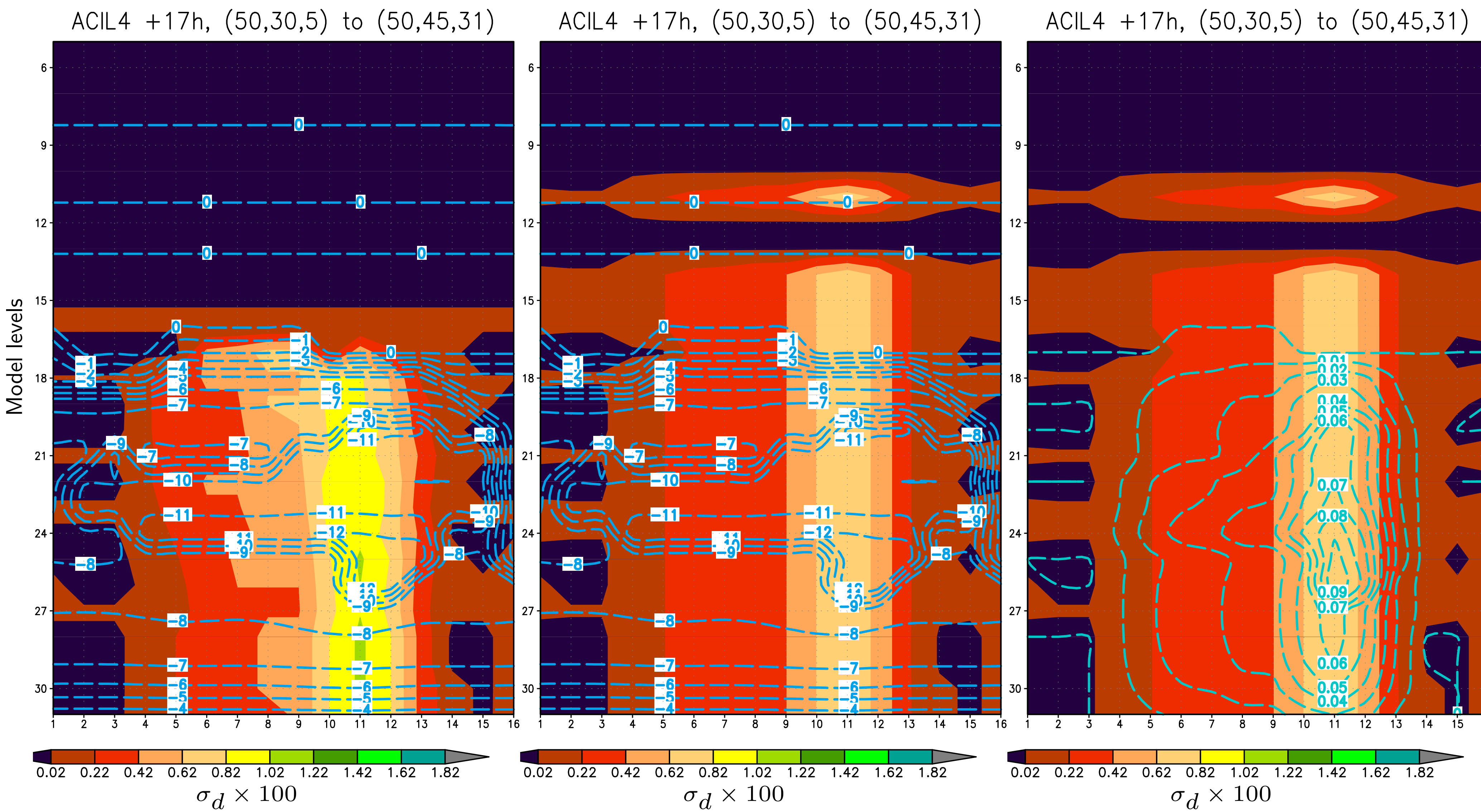
w_u, averaged σ_u, M_u



pseudo-historic convective cloud

vertical cross sections

The Tournai case



w_d, advected σ_d | w_d, averaged σ_d | M_d, averaged σ_d

downdraught vertical cross sections

Finally joining Timbuktu ?

– Advantages : light calculation, coherent integration of convection and microphysics, seems ready for grey zone.

– Further tests / tunings : varying the resolution, systematic validation

– Refine cloud profile calculation, prognostic entrainment, varying mesh fraction, microphysics.