The ALARO-0 physics: constraints and first steps.

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(on behalf of the many people which discussed & improved the ideas)

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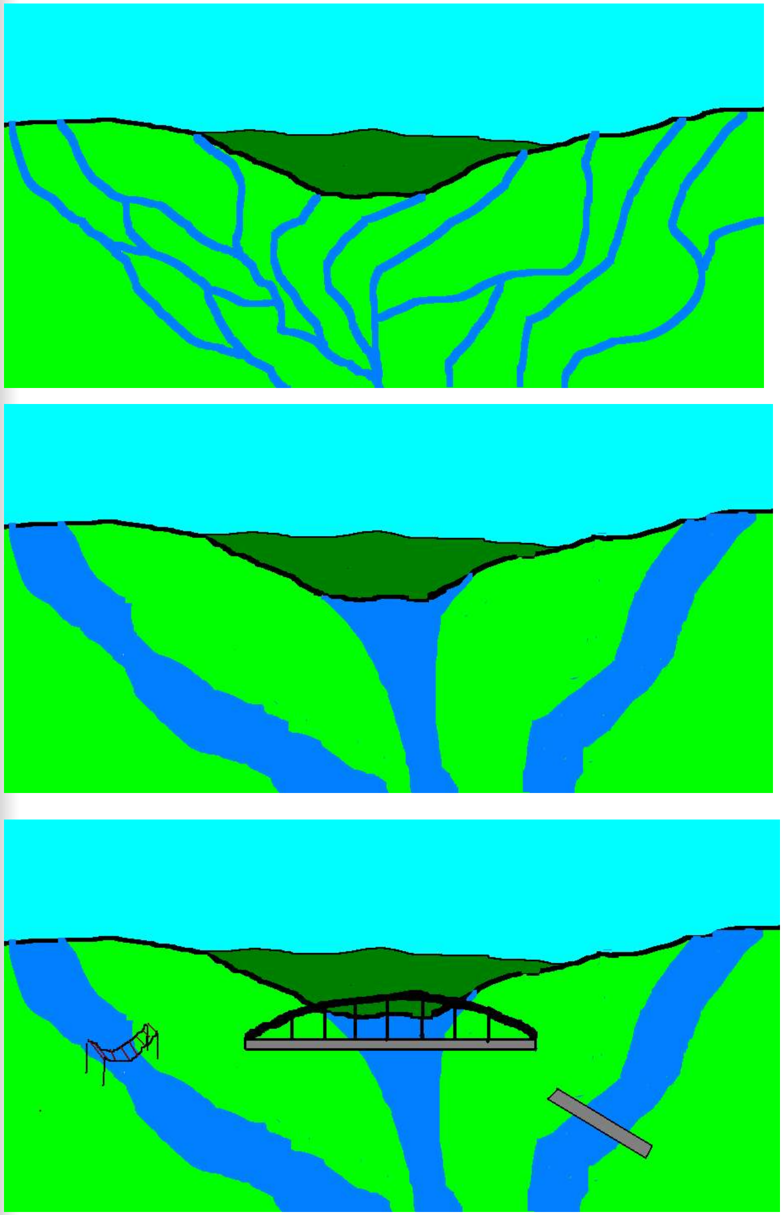
About the title of the talk (1/3)

The ‘zero’ after ‘ALARO’ does not mean that we are aiming at the sub-kilometric scale!!!

ALARO being now a development concept rather than a modelling goal, the ‘zero’ indeed means ‘beta-version’, fully in the spirit of the new interfacing equations.

Concerning the spirit of the work, it is neither AROME-10 nor ALADIN-2.5, but …

About the title of the talk (2/3)



We had confusion.

We went to ….

(Work) ***streams****.*

But with streams

you need …

Bridges*,*

big and small ones.

About the title of the talk (3/3)

The idea is indeed to build a <u>bridge</u> between techniques used to develop and operationalise parameterisation schemes at large & meso scales.

In a nutshell, the (low) sophistication and the long time-steps of the current ALADIN <u>together</u> with the algorithmic challenges of AROME.

No competition with AROME. Simply a proposal to look differently at the long term	Should please deciders who are believing that NH-model = having the same output as MM5

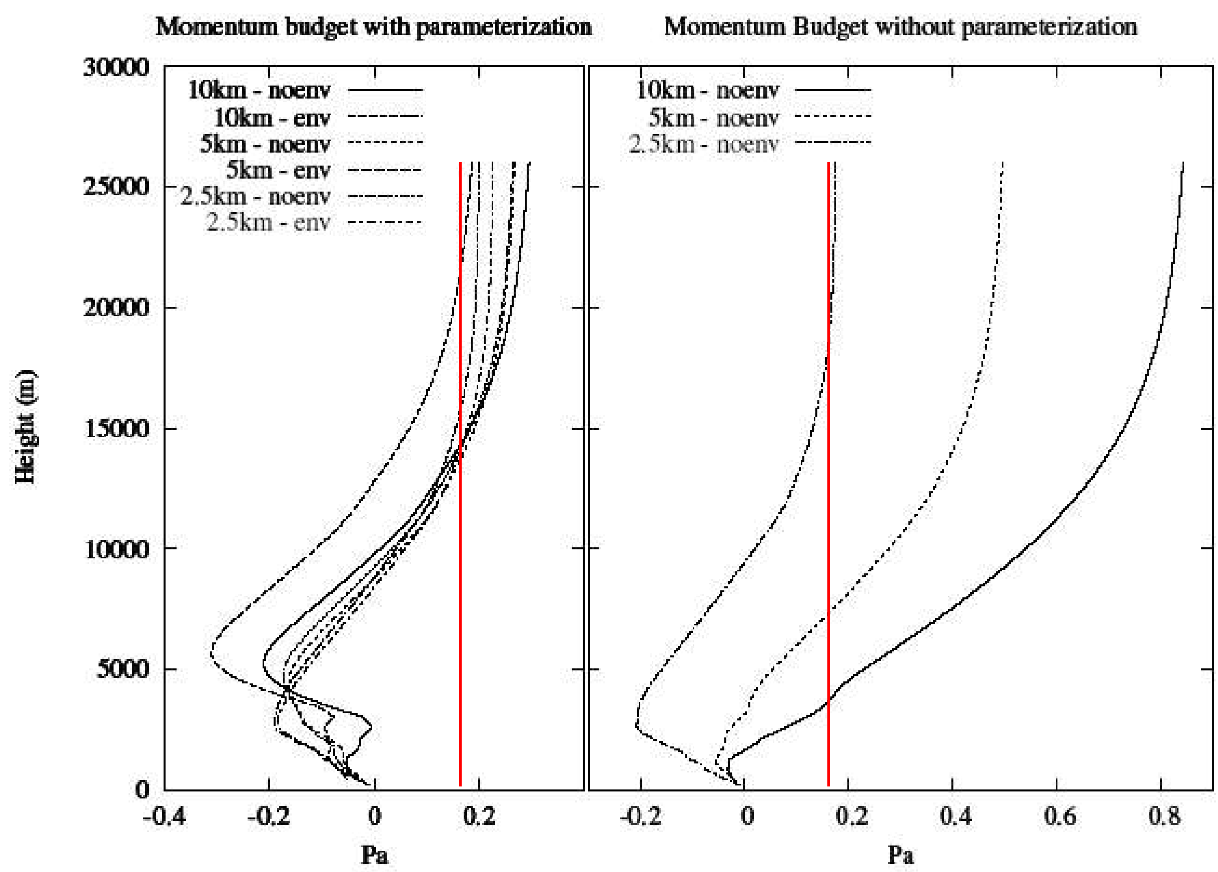
Outline of the remaining of the talk

- Mountain sub-grid effects (for the record)
- Radiation (for the spirit of the previous work)
- Large … work for mic…
- Progr…
- Precip…
- Other issues (non-precipitating convection, etc.)
- Conclusions

How other viewing angles can bring in better algorithmics and vice-versa

Mountain sub-grid effects (1/2)

ALPIA test



As they are parameterised now, such effects must be considered down to at least 5km of δx (recall of last year's talk by Bart Carty)

Mountain sub-grid effects (2/2)

- The new system is operational in ALADIN at CHMI (at least):
  - Removal of the envelope orography;
  - More consistent definition of wave- and form-drag components;
  - ‘Lift’ now correctly acting on the geostrophic wind.
- Papers (*Evolutions of the mountain drag/lift parameterisation scheme in ARPEGE/ALADIN*) submitted:
  - Part I: Geleyn, Bouyssel, Catry, Beau, Brozkova & Drvar
  - Part II: Catry, Geleyn, Bouyssel, Cedilnik, Dejonghe, Derkova & Mladek
- 10 people out of 6 ‘local teams’ for this article !!
- Code and draft papers available on request …

Radiation (1/4)

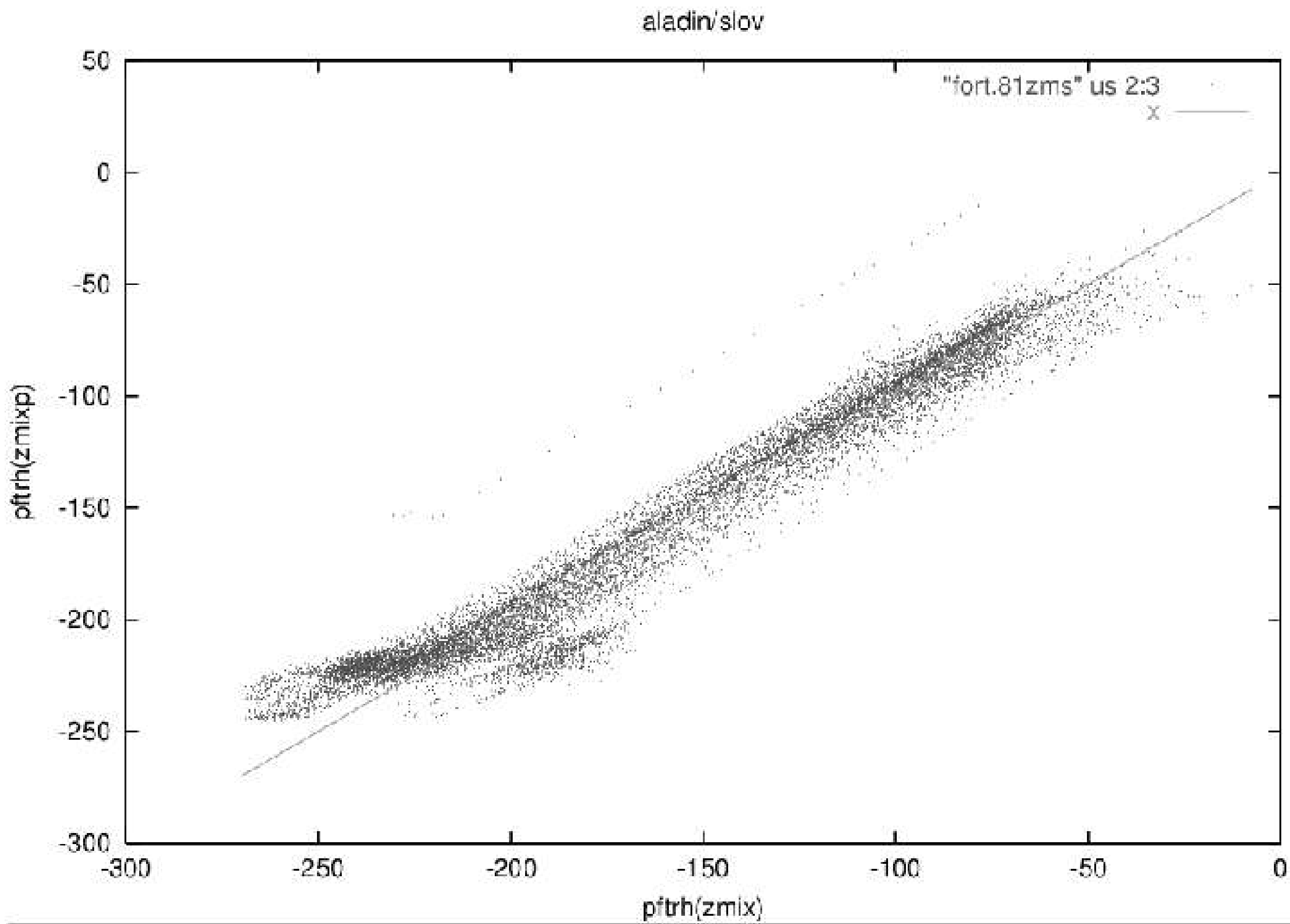


Figure: Dispersion diagram of thermal fluxes. X-axis: exact values. Y-axis : retrieved values from the parametrisation.

Radiation (2/4)

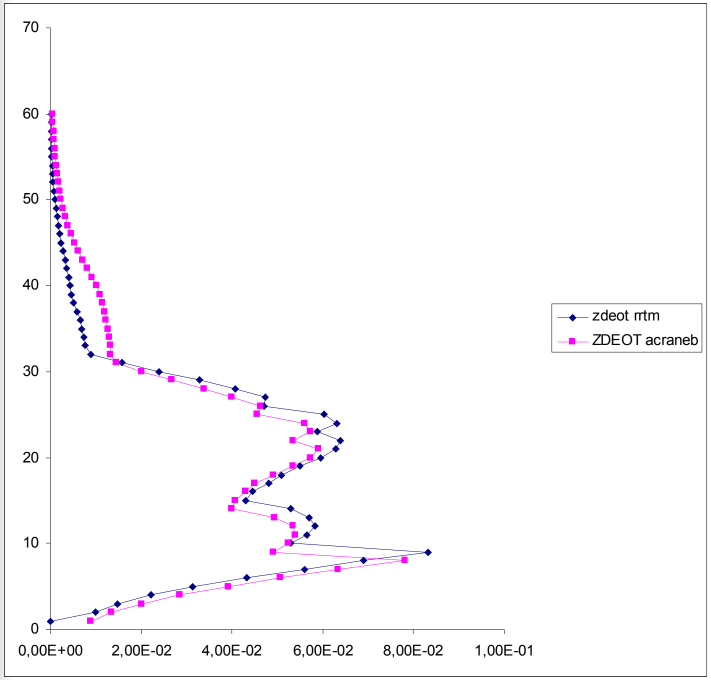
- Basic principles 'acted' in the WGNE 'blue-book': http://www.cmc.ec.gc.ca/rpn/wgne/, 2005 issue, page 4-07. A new 'bracketing' technique for a flexible and economical computation of thermal radiative fluxes, scattering effects included, on the basis the Net Exchanged Rate (NER) formalism (Geleyn, Fournier, Hello & Pristov).
- Reminder, NER offers the framework for:
  - A differentiation between 'expensive' but 'steady' computations of gas transmission functions and 'cheaper' updates with 'quickly varying' clouds, etc.
  - A clean framework for the vertical staggering of fluxes and temperatures as well as a vehicle for time-stable computations on thin layers.
- Hence, very much in the ALARO-0 spirit.
- Not much work since Innsbruck though …

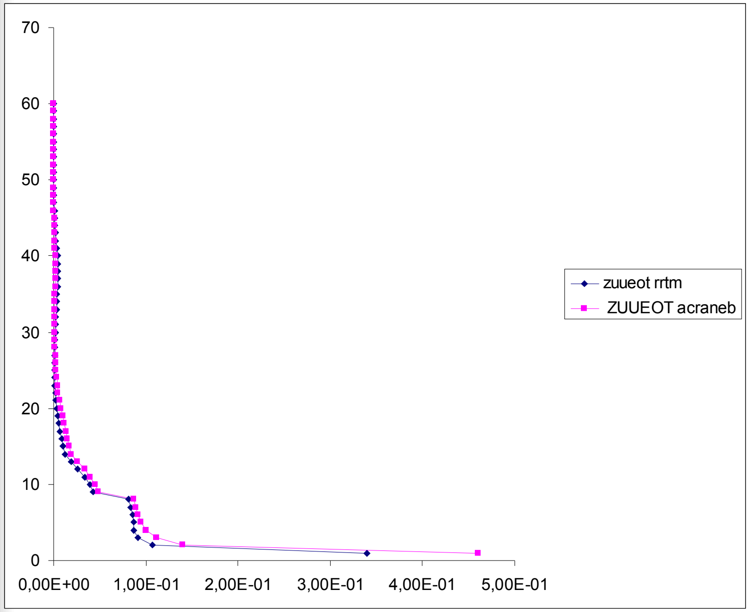
Radiation (3/4)

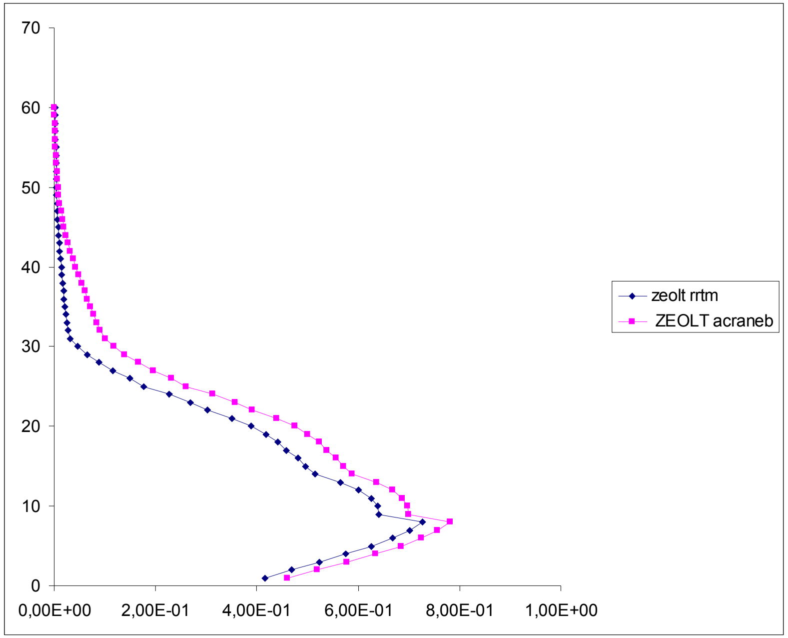
- ‘To do’ list:
  - A bit more complexity in the ‘statistical model’;
  - Introduction of the complete aerosol model;
  - Having the ‘Doppler broadening effect’ included; by-product of the NER work:

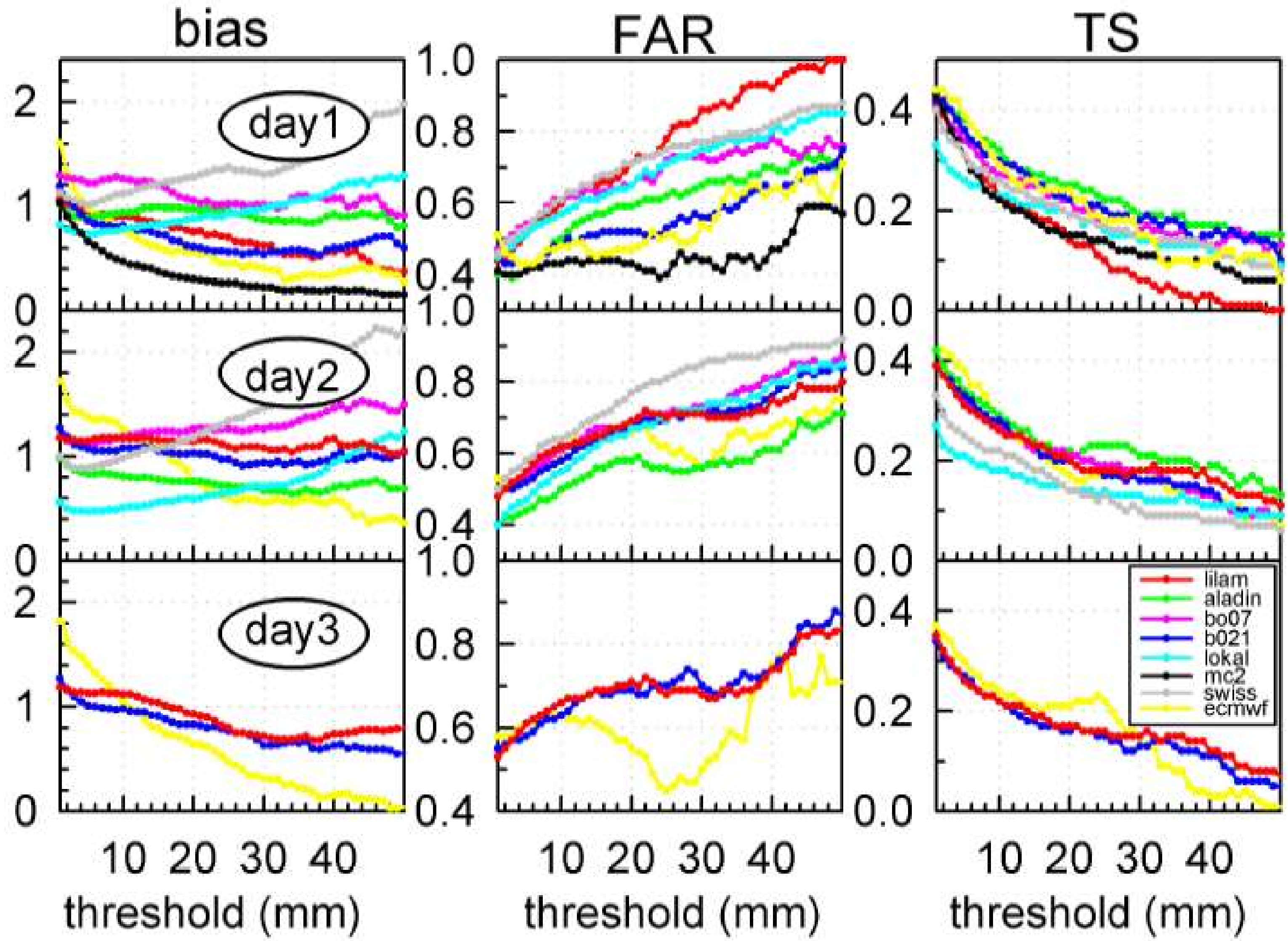
    Geleyn, Bénard & Fournier, 2005: A general-purpose extension of the Malkmus band-model average equivalent width to the case of the Voigt line-profile. Accepted in QJRMS.
  - Modularisation and hierachisation of the gaseous transmission functions (next dia).

Radiation (4/4)









Pedemonte et al., 2003

Target: keeping this quality but going fully prognostic

Large scale precipitation (1/2) ('ACPLUIE_prog')

- The idea is to start from the current version of ACPLUIE, and to add (in one go) a prognostic treatment of q_l, q_i, q_r and q_s with all relevant fluxes and pseudo-fluxes.
- We already have equations of the flux vs. flux-divergence type for:
  - Evaporation of precipitations

$$\frac{d\sqrt{R}}{d(1/p)} = E_{vap}.(q_w - q)$$

  - Melting of precipitations

$$\frac{d\,m_i}{d(1/p)} = F_{ont}.(T - T^*)/\sqrt{R}$$

Large scale precipitation (2/2) ('ACPLUIE_prog')

- We now also need similar equations for (at least):
  - Auto conversion $$\frac{dq_{l/i}}{dt} = -\frac{q_{l/i}}{\tau(T)}$$
  - Collection efficiency $$\frac{dR^{1/5}}{dp} = C_{oll} \cdot q_l$$
  - Link between flux and mean fall-speed $$\overline{w} = w_0 \cdot \left(\frac{R}{\rho^4} \right)^{1/6}$$
- **But the main problem is that of advective sedimentation**

A new approach for sedimentation of prognostic precipitation species [joint work with Yves Bouteloup (1/3)]

- If one accepts that sedimentation has to be treated with a single velocity and dynamics-like methods:
  - Eulerian schemes are expensive (iterations);
  - Lagrangian schemes are cumbersome (double loops and complex trajectory handling).
- But why shouldn't one quit this framework and start thinking in terms of spectra of fall velocities and hence of Probability Distribution Functions (PDF) of travelled distances in one time step ?

A new approach for sedimentation of prognostic precipitation species [joint work with Yves Bouteloup (2/3)]

- At first sight it is stupid, one has now an infinity of trajectories to handle !
- But, if the PDF is assumed to be of the decreasing exponential type:
  - For a given origin, the mean expected distance remains the same after each re-normalisation (there are simply less droplets likely to travel it)
  - The linked PDF is homothetic to the ones of other origins and can be linearly recombined with them at the bottom of each layer (and passed as a single one to the top just below)!

A new approach for sedimentation of prognostic precipitation species [joint work with Yves Bouteloup (3/3)]

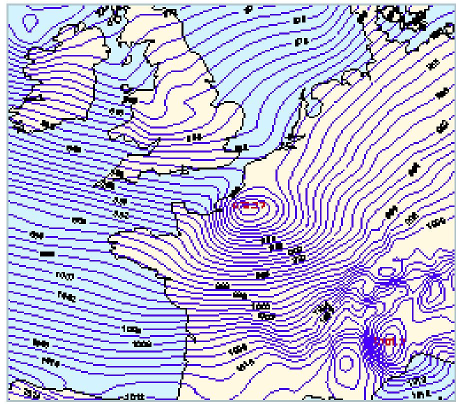
- With this trick, one replaces the ***advective*** treatment of sedimentation by a ***statistical*** one, without any loss of generality.
- The framework for 'ACPLUIE_prog' gets streamlined.
- Moreover, this new algorithm may be applied to any type of micro-physical scheme which equations can undergo 'tendencies ⇔ flux' conversions.

Hopefully, we can keep the advantages of the good present operational tuning, while having a more realistic treatment of the interaction between dynamics and thermodynamics (less upslope and more downslope precipitations for instance)

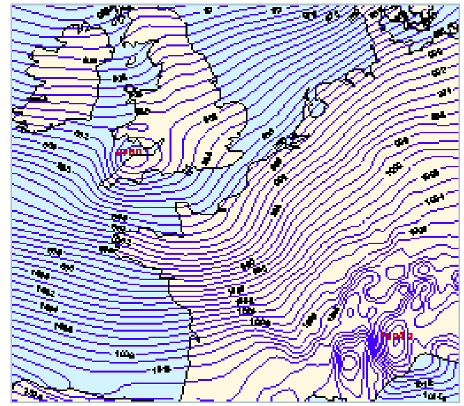
IMPACT DES MODIFICATIONS "CYCORA"

CYclogénèse COnvection RAyonnement (19/10/1999)

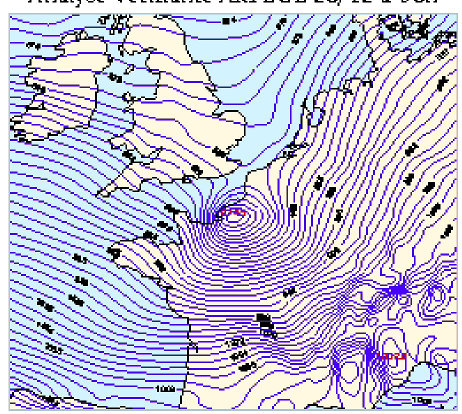
ARPEGE CYCORA 25/12 00h +30h



ARPEGE SANS CYCORA 25/12 00h +30h



Analyse vérifiante ARPEGE 26/12 à 06h



Target: keeping this quality but going TKE prognostic

Prognostic TKE (1/4) ('ACCOEFK_prog')

- Basic Turbulent Kinetic Energy (E) prognostic scheme:

$$\frac{dE}{dt}=A_{dv}(E)+\frac{1}{\rho}\frac{\partial}{\partial z}\rho K_E\frac{\partial E}{\partial z}+\boxed{Shear\_prod+Buoyancy\_prod/destr-\frac{C_\varepsilon E^{3/2}}{L_\varepsilon}}$$

$$K_m=C_K L_K\sqrt{E} \qquad K_h=C_H L_K\sqrt{E}\Phi_3(R_i) \qquad K_E=\alpha K_M\frac{\Phi_E(z/L)}{\Phi_M(z/L)}$$

Louis-type scheme ⇔ this box ≡ 0

If we believe that, for the 5-10km scales, we have a well-tuned (but too static) scheme for diagnostic values of K_m and K_h (Louis' scheme), why not inverting the process?

Prognostic TKE (2/4) (‘ACCOEFK_prog’)

- But how to do this inversion?
  - Replacing the red box by a Newtonian relaxation with the τ_ε time scale of the dissipation term (the last one of the box).
  - Inverting the ***E => K*** idea into a corresponding ***K_diag => E_target*** one!
  - Making simple for the replacement of the ‘Φ’ functions for the dependence on static stability.

$$\frac{dE}{dt} = A_{dv}(E) + \frac{1}{\rho}\frac{\partial}{\partial z}\rho K_E \frac{\partial E}{\partial z} + \boxed{Shear\_prod + Buoyancy\_prod/destr - \frac{C_\varepsilon E^{3/2}}{L_\varepsilon}}$$

$$K_m = C_K L_K \sqrt{E} \qquad K_h = C_H L_K \sqrt{E}\,\Phi_3(R_i) \qquad K_E = \alpha K_M \frac{\Phi_E(z/L)}{\Phi_M(z/L)}$$

Prognostic TKE (3/4) ('ACCOEFK_prog')

- The symbolic algorithm (with tilded values for the 'static' part): $\widetilde{K}_m(ACCOEFK) \Rightarrow \widetilde{E}, K_E, \tau_\varepsilon$

$$dE/dt = f(E, \widetilde{E}, K_E, \tau_\varepsilon)$$

$$E \Rightarrow K_m$$

$$K_m, \widetilde{K}_m, \widetilde{K}_h(ACCOEFK) \Rightarrow K_h$$

- The simplification for the static stability effects: $K_h = K_m.(\widetilde{K}_h / \widetilde{K}_m)$

$$K_E / K_m = K_E(R_i = 0) / K_m(R_i = 0)$$

- Some rewriting: $L_K = A_K.l_m \qquad L_\varepsilon = A_\varepsilon.l_m$

Prognostic TKE (4/4) ('ACCOEFK_prog')

$$\frac{dE}{dt} = A_{dv}(E) + \frac{1}{\rho}\frac{\partial}{\partial z}\rho K_E \frac{\partial E}{\partial z} + \frac{1}{\tau_\varepsilon}(\tilde{E} - E)$$

$$K_m = C_K L_k \sqrt{E} = C_K A_K \frac{l_m}{\kappa}\sqrt{E} \Leftrightarrow \tilde{E} = \left(\frac{\kappa \tilde{K}_m}{C_K A_K l_m}\right)^2$$

$$K_E = \alpha K_m$$

$$\frac{1}{\tau_\varepsilon} = \frac{C_\varepsilon \sqrt{E}}{L_\varepsilon} = \frac{C_\varepsilon \kappa \sqrt{E}}{A_\varepsilon l_m}$$

But how to choose C_K, A_K, C_ε and A_ε in order to have a meaningful scheme for all l_m values ?

An extension of the proposal of Redelsperger, Mahé & Carlotti

- RMC01 proposed a way to compute the A and C coefficients such as to have continuity with the Monin-Obukov formulae near the surface:

$$A_K = \frac{1}{\sqrt{\alpha}} \frac{\kappa}{C_K} = A_\varepsilon = \alpha \sqrt{\alpha} \kappa \, C_\varepsilon$$

Extending this to all layers, the result is beautifully simple:

$$K_m = \nu \, l_m \sqrt{E} \quad \Leftrightarrow \quad \tilde{E} = \left(\frac{\tilde{K}_m}{\nu \, l_m} \right)^2$$

$$K_E = \frac{l_m \sqrt{E}}{\nu} = \frac{K_m}{\nu^2} \qquad \textit{with} \quad \nu = 1/\sqrt{\alpha} \approx 0.5$$

$$\frac{1}{\tau_\varepsilon} = \frac{\nu^3 \sqrt{E}}{l_m} = \nu^2 \frac{K_m}{l_m^2}$$

Hopefully, we can keep the advantages of the good present operational tuning, while having a clean test-bed for studying:

-the time stability of the prognostic algorithm at long time-steps

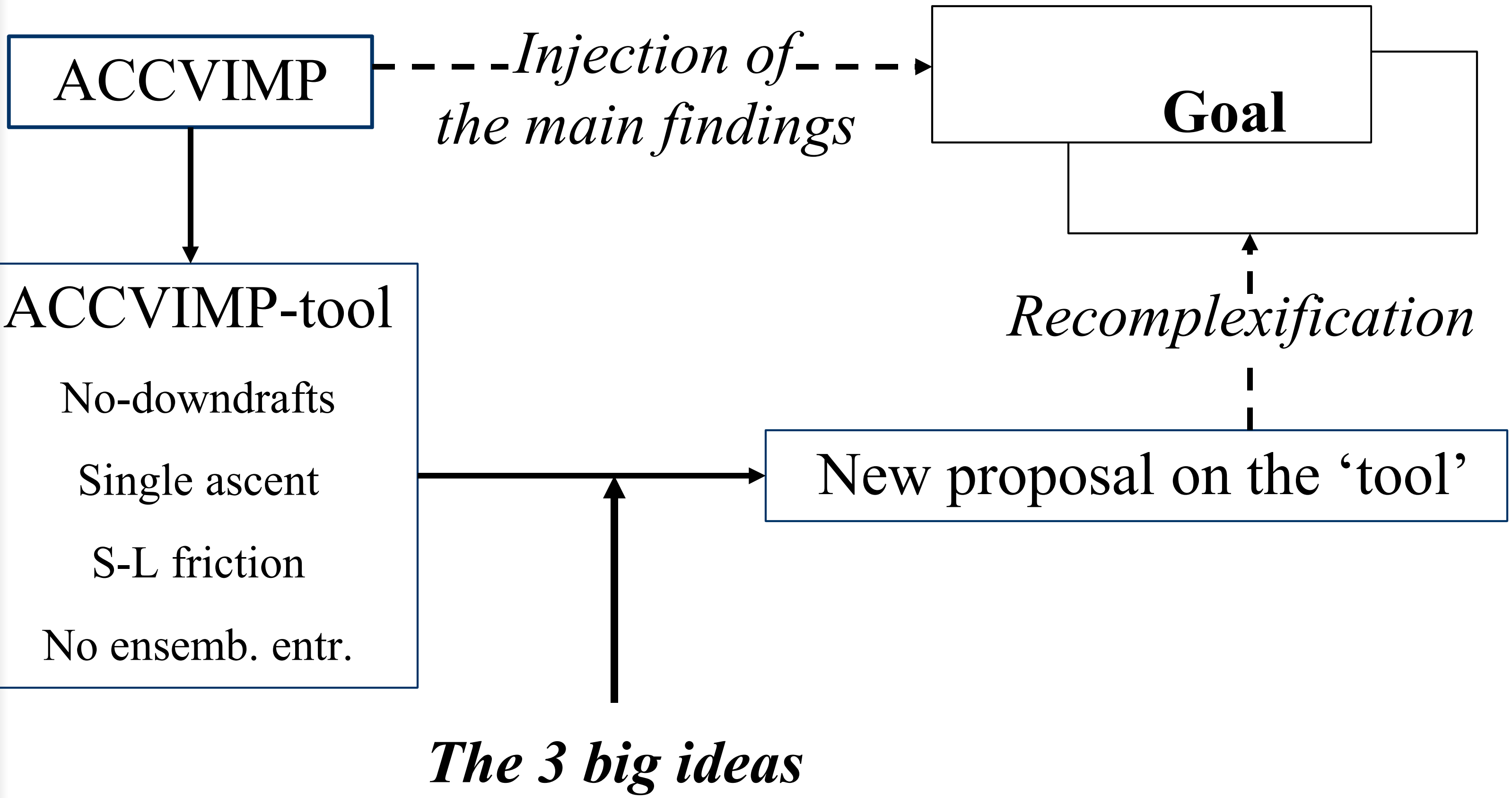
-the vertical staggering problem of E and K

- the role of an antifibrillation scheme in this prognostic context

Convection: main findings from the PhD work of Jean-Marcel Piriou

- One should stop trying to answer the question *‘which are the quantities that convection leaves unchanged?’* and rather go to *‘which convective clouds are likely to develop in a given environment?’*
- This leads to the concept of Bulk Convective Condensation (BCC) as a link between the diagnostic of such ‘model-clouds’ and the closure of the scheme.
- The parameter that becomes crucial in this vision is not any more the mass-flux but the entrainment rate.

Convection: how to integrate that new angle in ALARO-0 ?



Other issues

- The ***shallow convection*** issue has been put aside for a while, because:
  – Jean-Marcel Piriou thinks his new framework may be an answer in itself (similarity with Soares et al., allowing a convergence);
  – The GMAP/PROC work with Lopez scheme was kept compatible with the current LCVPP scheme;
  – There is an obvious link with the march towards the grey zone (Luc Gerard’s work);
  – One may need to think even further in time along the lines of the Tartu workshop’s conclusions.
- This latter point brings back to:
  – The link between condensation/precipitation and turbulence;
  – Interfacing and physics **‘hierarchisation of options’**.

Conclusion

- There is at last an ALARO-physics' definition and structure of work that is driven by longer-term considerations !
- Let us not:
  - Underestimate the immediate challenge;
  - Forget the link with interfacing;
  - Be diverted by 'fun-bringing' considerations;
  - Compromise on the specificities:
    - Long time-steps test-bed;
    - Upward operational compatibility;
    - First brick for a potential new view of physics' development and maintenance.
- Volunteers welcome (& seriously needed).