DDH: a physics-dynamics budget tool for ARPEGE, ALADIN and AROME.

Jean-Marcel Piriou and Tomislav Kovacic.
Météo-France and IMSC (Croatia).
*HIRLAM / ALADIN All-Staff Meeting / Workshop, 2007-04-24.*

DDH: Diagnostics on Horizontal Domains: a generic tool to provide budget of prognostic variables, to develop physics, understand physico-dynamical interactions.
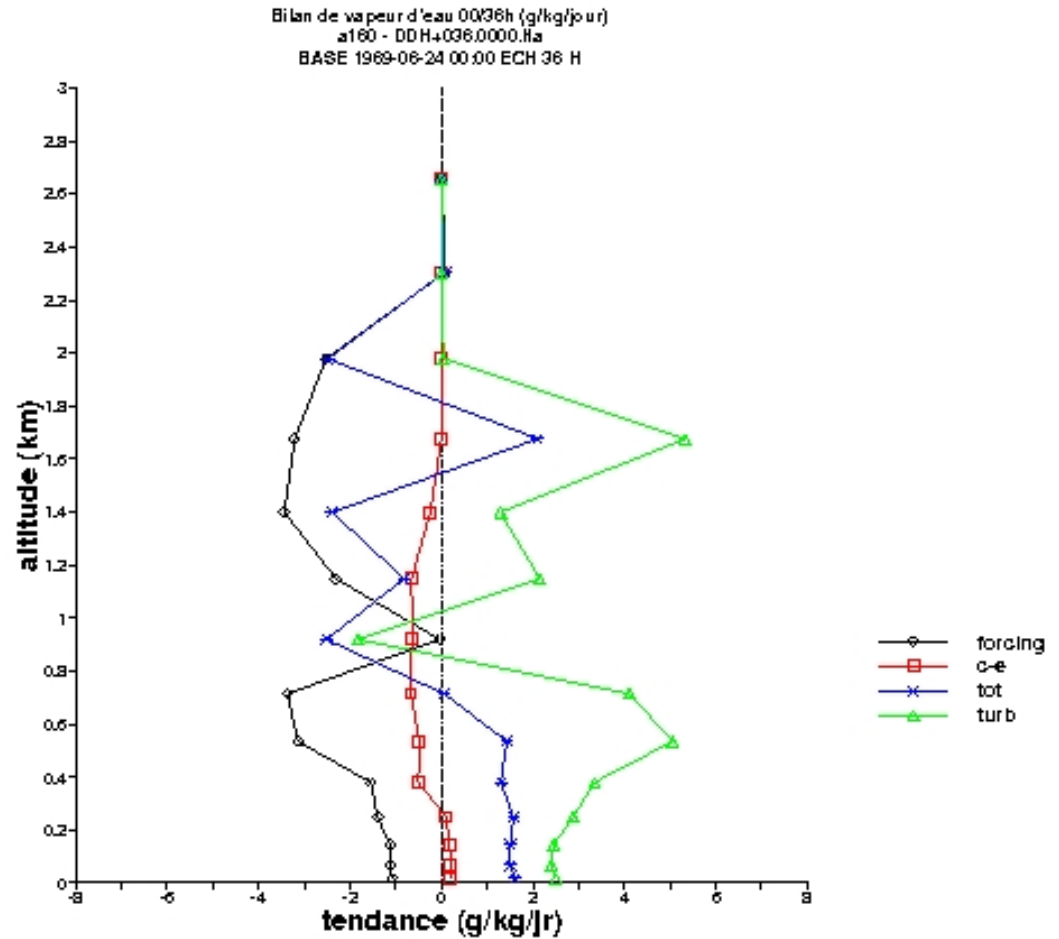
DDH tool: used in ARPEGE and ALADIN since 1992, for research and operations.

Ongoing effort in the ALADIN community to further update and develop: soon available in AROME, update to new
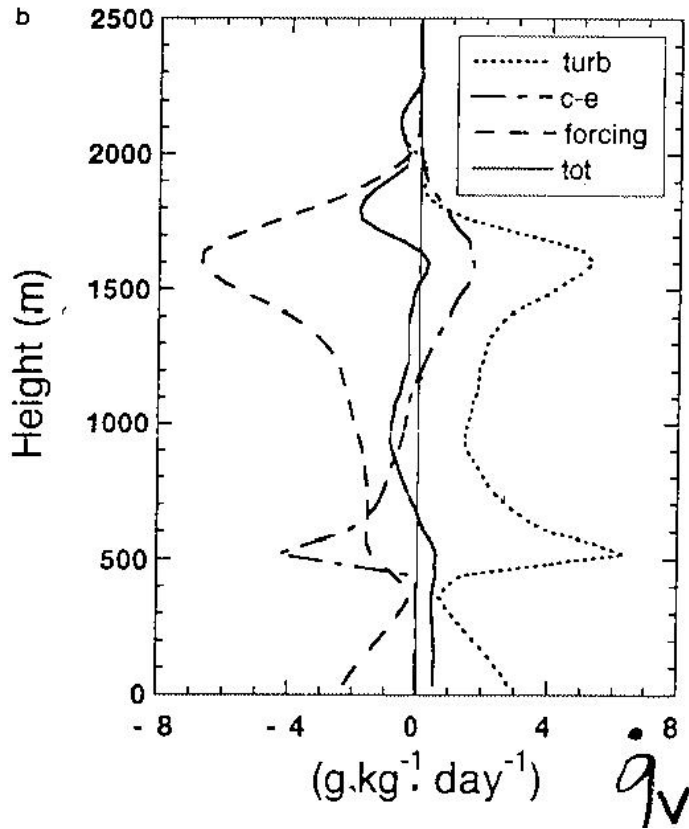
LES 3D, Siebesma et Cuijpers 1995

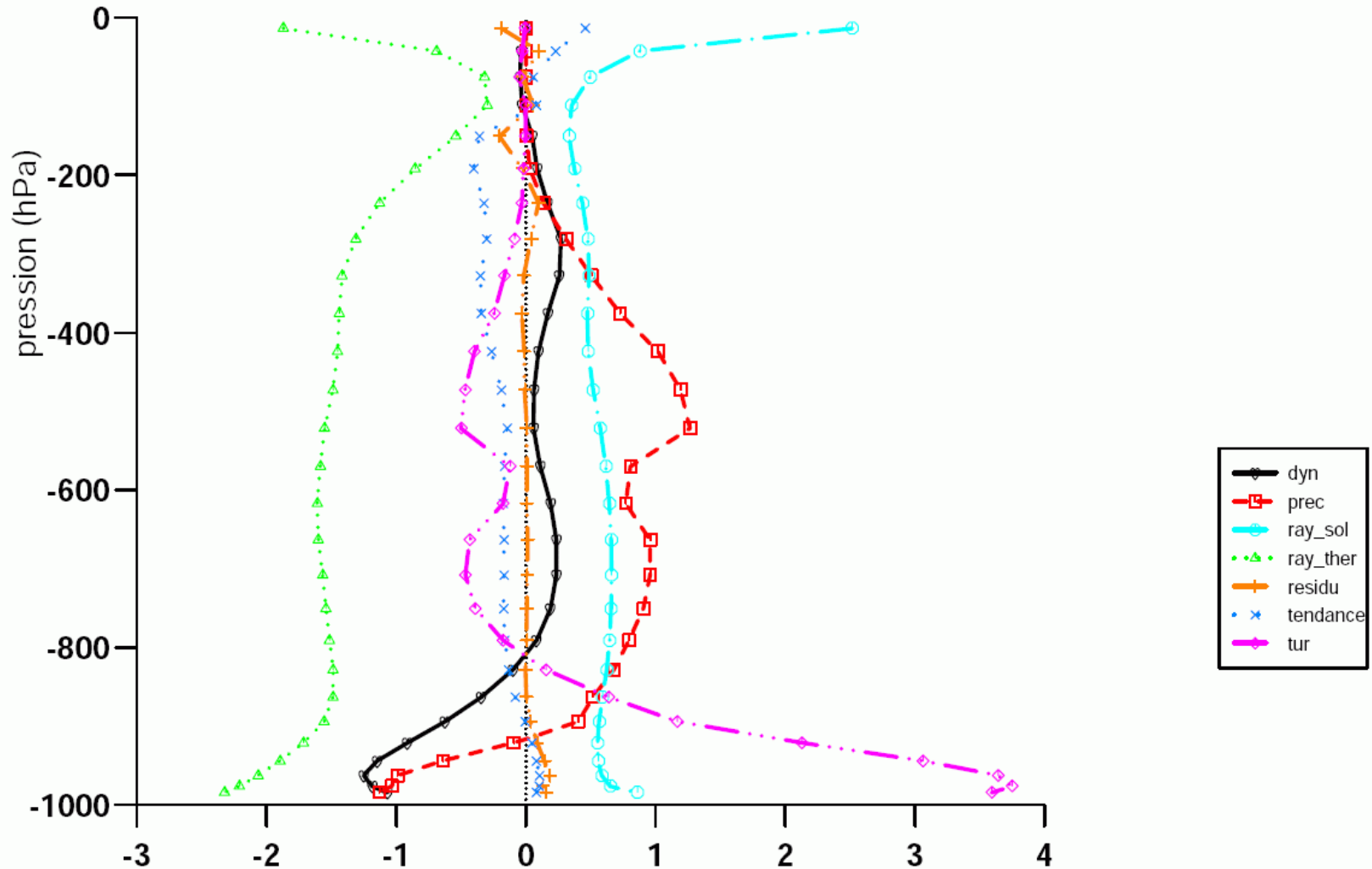ARPEGE-ALADIN 1D model, DDH water vapour budget; physics: 3MT scheme, Alexandre Flouttard, Master UPS 2006

Bilan de température (K/jour)

arpege_oper_cycle - DL.lfa

BASE 1997-01-01 00:00 ECH 363 J

$$\frac{\partial}{\partial t}\left(r_\eta c_p T\right) = -\operatorname{div}_\eta\left(r_\eta c_p T \vec{v}\right) - \frac{\partial}{\partial \eta}\left(r_\eta c_p T \dot{\eta}\right) + r_\eta R T \frac{\omega}{p}$$

$$+\frac{\partial}{\partial \eta}\left\{ F_h + F_{hp} + F_p^l T\left[c_l - c_{p_a}(1-\delta_m)\right] + F_p^n T\left[c_n - c_{p_a}(1-\delta_m)\right]\right\}$$

$$+\delta_m F_p \frac{\partial\left(\Phi + \dfrac{u^2 + v^2}{2}\right)}{\partial \eta} - \vec{v}\cdot\frac{\partial \vec{F}_v^{phys}}{\partial n} \tag{4.3}$$

Example of enthalpy budget. Also available: dry air mass, water species, kinetic energy, angular momentum, entropy, etc.

VCT0	$\frac{1}{g} c_p T \delta p$ (t=0)	
VCT1	$\frac{1}{g} c_p T \delta p$ (t= NSTEP δt)	
TCTDIVFLUHOR	$-\frac{\delta t}{g}\operatorname{div}_\eta\left(c_p T \delta p\, \vec{v}\right)$	cumul
TCTCONVERSI2	$\frac{\delta t}{g} R T \delta p(\omega/p)$	cumul
TCTCONVERSI3	$-\delta_m \delta t F_p \delta\Phi$	cumul
FCTFLUVERTDYN	$\frac{\delta t}{g} c_p T \dot{\eta}\frac{\partial p}{\partial \eta}$	cumul
FCTTUR	$\delta t\, F_s^{tur}$	cumul
FCTTURCONV	$\delta t\, F_s^{tur-conv}$	cumul
FCTRAYSOL1	$\delta t\, F_h^{sol}$	cumul
FCTRAYTER1	$\delta t\, F_h^{ther}$	cumul
FCTMESO	$\delta t\, F_h^{meso}$	cumul
FCTPRECISTL	$-\delta t\, F_{hp}^{stra-l}$	cumul
FCTPRECISTN	$-\delta t\, F_{hp}^{stra-n}$	cumul
FCTPRECICOL	$-\delta t\, F_{hp}^{conv-l}$	cumul
FCTPRECICON	$-\delta t\, F_{hp}^{conv-n}$	cumul
FCTPRECCSCOL	$-\delta t\, F_p^{conv-l} T\left[c_l - c_{p_a}(1-\delta_m)\right]$	cumul
FCTPRECCSCON	$-\delta t\, F_p^{conv-n} T\left[c_n - c_{p_a}(1-\delta_m)\right]$	cumul
FCTPRECCSSTL	$-\delta t\, F_p^{stra-l} T\left[c_l - c_{p_a}(1-\delta_m)\right]$	cumul
FCTPRECCSSTN	$-\delta t\, F_p^{stra-n} T\left[c_n - c_{p_a}(1-\delta_m)\right]$	cumul

DDH domains available

DDH domains available
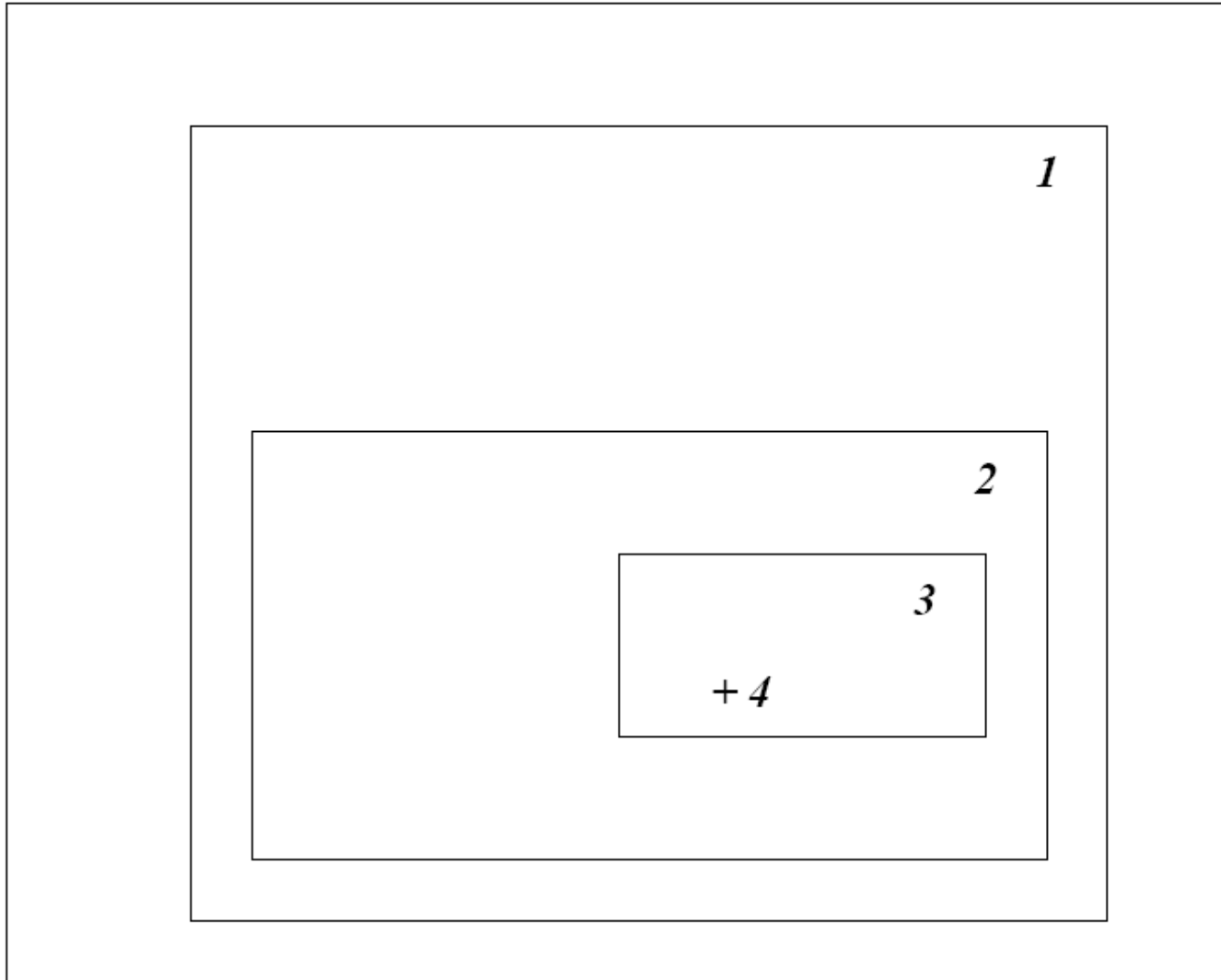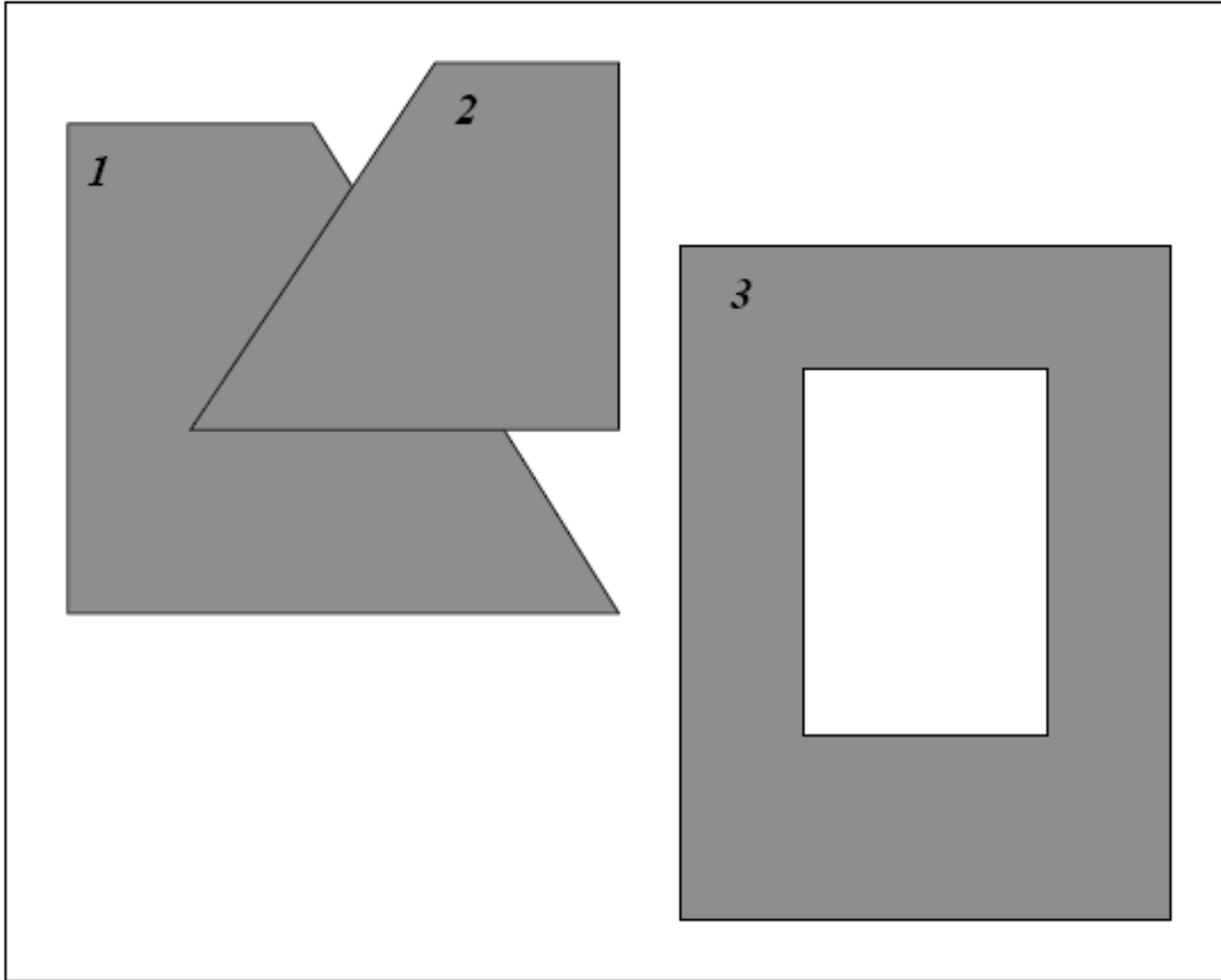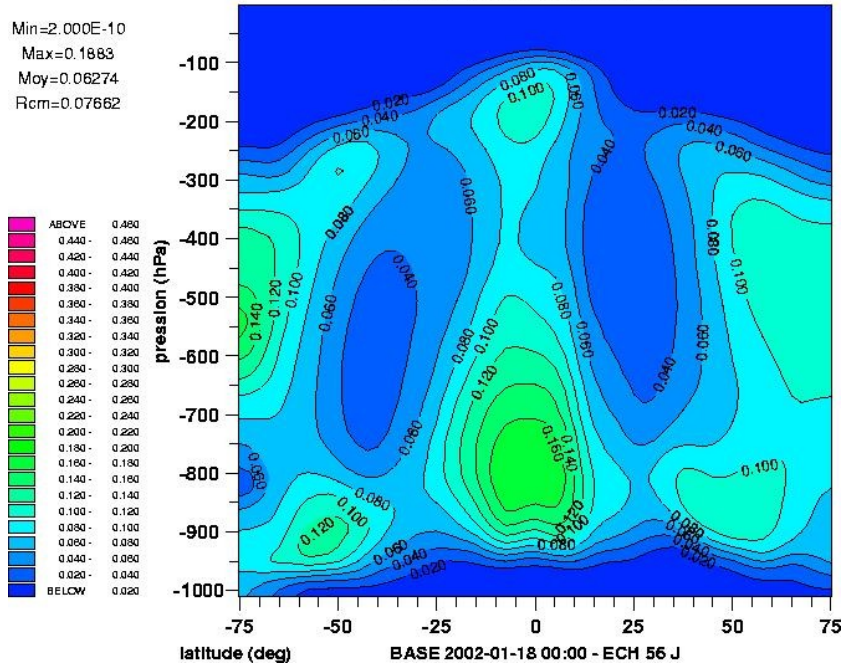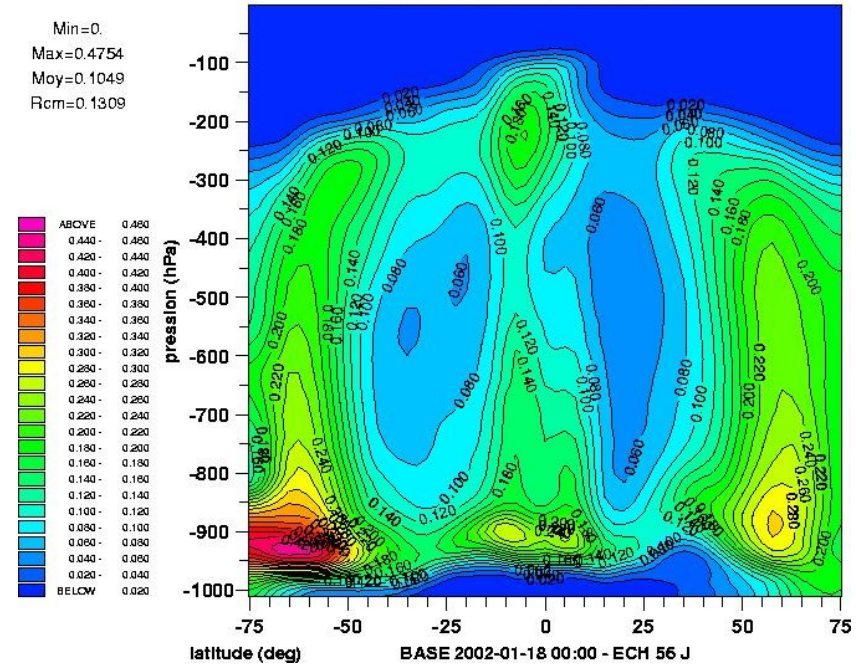
ARPEGE 3D, zonal DDH bands, cloudiness, 2002. LHS: control scheme, RHS: exp scheme after Xu and Randall 1996

OLD

NEW

- Models: ARPEGE and ALADIN.

- User-defined domains: zonal bands, rectangular areas, polygonal areas, single vertical profiles (sampling), cross-sections.

- Variables: diagnostic, prognostic (budget).

- Used since 1992.

Develop and tune physics: based on case studies, DDH is a tool to understand what the model does:

- Interaction between parameterizations, between physics and dynamics.

- Study steady state, or transitory state, instabilities, etc.

- Difference between a control and a modified run.

- Monitor biases (differences between guess and analysis, spin-up studies, etc).

- ## Interface AROME physics with DDH (Tomislav Kovacic).

Microphysical process	vapour	cloud water	rain	cloud ice	snow	graupel	enthalpy
water vapour adjustment		F_{ql}^{cdepi}		F_{qi}^{cdepi}			F_h^{cdepi}
heterogeneous nucleation	F_{qv}^{henu}			F_{qi}^{henu}			F_h^{henuv}
homogeneous nucleation		F_{ql}^{hon}		F_{qi}^{hon}			F_h^{honl}
spontaneous freezing			F_{qr}^{sfrz}			F_{qg}^{sfr}	F_h^{sfr}
deposition on snow	F_{qv}^{deps}				F_{qs}^{dep}		F_h^{deps}
collection of ice on snow				F_{qi}^{agg}	F_{qs}^{agg}		
auto-conversion of ice to snow				F_{qi}^{autoi}	F_{qs}^{autoi}		
deposition on graupel	F_{qv}^{depg}					F_{qg}^{dep}	F_h^{depg}
auto-conversion of cloud water		F_{ql}^{autor}	F_{qr}^{autor}				
accretion		F_{ql}^{accr}	F_{qr}^{accr}				
rain evaporation	F_{qv}^{reva}		F_{qr}^{reva}				F_h^{reva}
riming by cloud droplets		F_{ql}^{rim}			F_{qs}^{rim}	F_{qg}^{rim}	F_h^{rim}
collection of raindrops			F_{qr}^{accs}		F_{qs}^{accs}	F_{qg}^{accs}	F_h^{accs}
melting of aggregates					F_{qs}^{cmel}	F_{qg}^{cmel}	
contact freezing			F_{qr}^{cfrz}	F_{qi}^{cfrz}		F_{qg}^{cfrz}	F_h^{cfrz}
wet growth		F_{ql}^{wetg}	F_{qr}^{wetg}	F_{qi}^{wetg}	F_{qs}^{wetg}	F_{qg}^{wetg}	F_h^{wetg}
dry growth		F_{ql}^{dryg}	F_{qr}^{dryg}	F_{qi}^{dryg}	F_{qs}^{dryg}	F_{qg}^{dryg}	F_h^{dryg}
melting of graupel			F_{qr}^{mltg}			F_{qg}^{mltg}	F_h^{mltg}
melting of cloud ice		F_{ql}^{mlti}		F_{qi}^{mlti}			F_h^{mlti}
Bergeron-Findeisen effect		F_{ql}^{berfi}		F_{qi}^{berfi}			F_h^{berfi}

- DDH diagnose the Catry-Geleyn interface's pseudo fluxes (TK).

- Validate how accurate the budgets are (residuals) in AROME, if current CPTEND used for temporal integration (TK, JMP).

- Make model temporal integration from the Catry-Geleyn pseudo-fluxes ➔ smaller residuals (JMP).

- Translate to English present DDH documentation, write doc new features (TK, JMP).

- Develop PostDDH tools (accumulate, differenciate, interpolate, budgetise, etc) to provide ready-to-plot budgets from DDH files, for the new AROME diagnostics.

- DDH: an efficient tool to develop and validate physics, used in ARPEGE – ALADIN since 1992.

- A significant effort still to be done in order:

  - To have the same level of diagnostics in AROME as in ARPEGE - ALADIN.

  - To generate a complete English documentation, and a portable PostDDH software (improve install process), so that the whole ALADIN community could use the DDH software, from generating DDH files up to ready-to-plot budget profiles.