RMI

Hirlam/Aladin All Staff meeting
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# Physics Organization: Cleaning and Convergence

Daan Degrauwe

with help from Y. Bouteloup, F. Bouyssel, R. Brožková,
C. Karadavut, J. Mašek, L. Rontu, Y. Seity, M. Szücs and P. Termonia

# Content



1. General context
2. Convergence of the physics-dynamics interface
3. Cleaning of physics calling routines
4. Conclusions and work ahead

# Context



During the previous workshop, several issues were raised that relate to the organization of the physics:

- What is Harmonie?
- Work on physics-dynamics interface is progressing slowly.
- Hirlam wants to compare several radiation schemes (IFS, acraneb(2), hlradia) in the same testbed.
- The APLPAR routine has become overly complex.

# Context



During the previous workshop, several issues were raised that relate to the organization of the physics:

- What is Harmonie?
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- The APLPAR routine has become overly complex.

$\Rightarrow$ an ambitious action has been started to tackle these issues together.

Regular follow-up and discussion between Hirlam, Météo-France, LACE and Aladin.

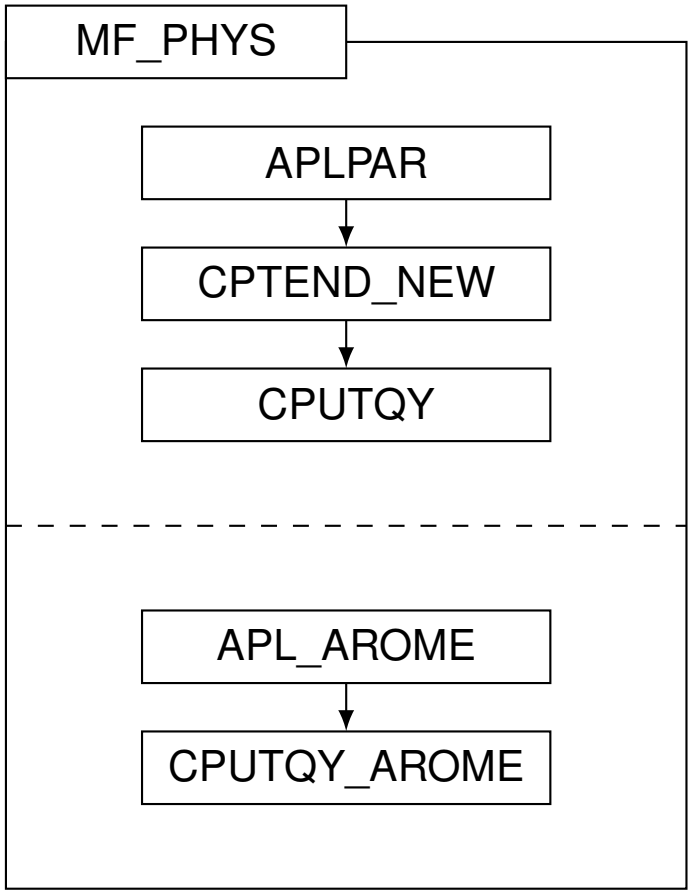
Reports, presentations and documentation can be found on wiki page:

https://hirlam.org/trac/wiki/phys-dyn

# Two physics packages



These issues are due to the fact that ALARO/ARPEGE and AROME are entirely separated:




*Calculate fluxes of prognostic variables*

*Convert fluxes to tendencies*

*Update prognostic variables*

*Calculate tendencies of prognostic variables*

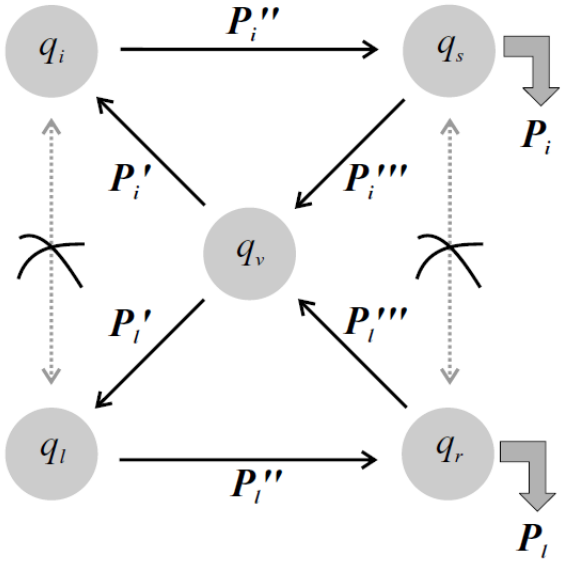
*Update prognostic variables*

- Different physics-dynamics interface: CPTEND_NEW/CPUTQY vs. CPUTQY_AROME
- Different calling routine: APLPAR vs. APL_AROME

# Physics-dynamics interface



- There are some differences in convention:
  - ARPEGE and ALARO use the enthalpy-flux-based Catry interface
  - AROME uses a temperature-tendency-based interface
- The AROME interface makes some approximations:
  - neglecting the heat transport by precipitation
  - neglecting the heat capacity change by turbulence and shallow convection
  - use of $c_{pd}$ instead of $c_p$ for radiative heating
- The Catry interface has a big advantage in terms of conservation and consistency, but it is quite rigid:
  - 4 prognostic hydrometeors
  - fixed set of fluxes




*(Courtesy of B. Catry)*

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- Development of flexible interface 'INTFLEX':
  - arbitrary number of hydrometeors
  - all conversions between hydrometeors are possible
  - tested during Working Week in Brussels
  - phased in cy40t1
- Also useful for ARPEGE/ALARO!

  PCMT scheme with convective hydrometeors, prognostic graupel, newly defined fluxes, ...

  Bonus: automatic detailed diagnostics at the level of the physics-dynamics interface.

# Interfacing AROME



- Three ways exist now to couple AROME physics to the dynamics:

1. Existing: temperature-tendency-based with the mentioned approximations:

$$\left(\frac{\partial T}{\partial t}\right)^{total} = \left(\frac{\partial T}{\partial t}\right)^{rad} + \left(\frac{\partial T}{\partial t}\right)^{diff} + \left(\frac{\partial T}{\partial t}\right)^{micro}$$

2. Reproducing the existing results with INTFLEX, by making the same approximations:

$$\left(\frac{\partial c_p T}{\partial t}\right)^{total} = -g\frac{\partial}{\partial p}\left[J^{rad} + J^{diff} + J^{micro} + J^{prec} + J^{fict}\right]$$

where $J^*$ are energy fluxes.

3. Discarding the approximations to obtain a more accurate system:

$$\left(\frac{\partial c_p T}{\partial t}\right)^{total} = -g\frac{\partial}{\partial p}\left[J^{rad} + J^{diff} + J^{micro} + J^{prec}\right]$$

where $J^{diff}$ is determined from $-g\frac{\partial J^{diff}}{\partial p} = c_p\left(\frac{\partial T}{\partial t}\right)^{diff}$.

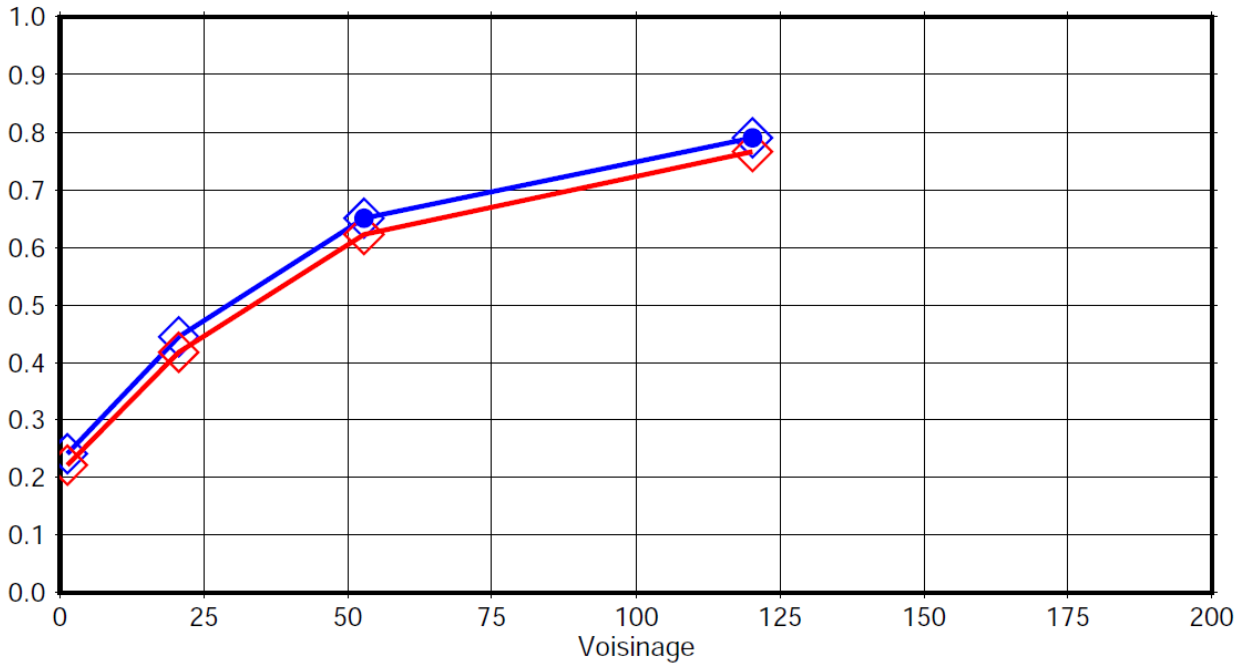
The impact on forecast quality remains to be investigated in detail, but first tests indicate rather small differences due to compensation effects between the approximations.

# Interfacing AROME: preliminar results



- Accounting for heat transport by precipitation:

Neighbourhood Observation Brier Skill Score for precipitation $> 10$ mm

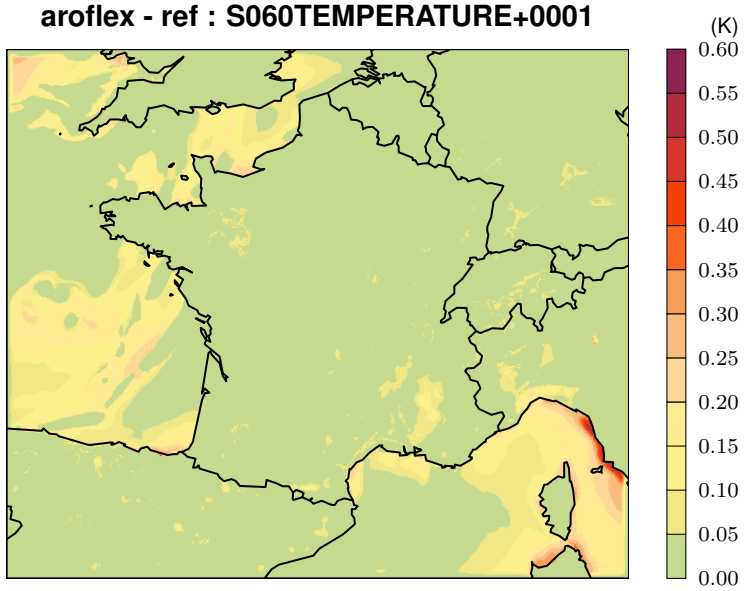



*(Courtesy of Y. Seity)*

# Interfacing AROME: preliminar results



- Accounting for $dc_p/dt$ in shallow convection scheme:




Difference between correct and approximated after 1 time step

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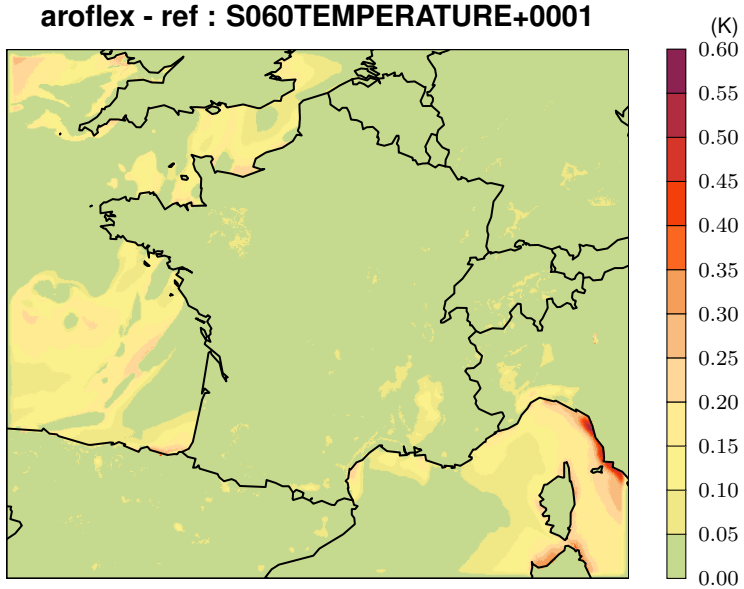


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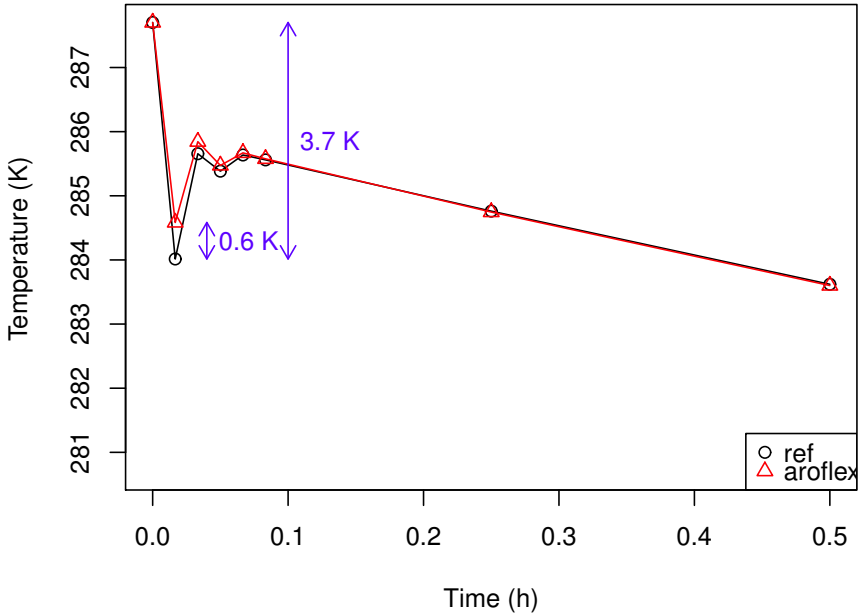


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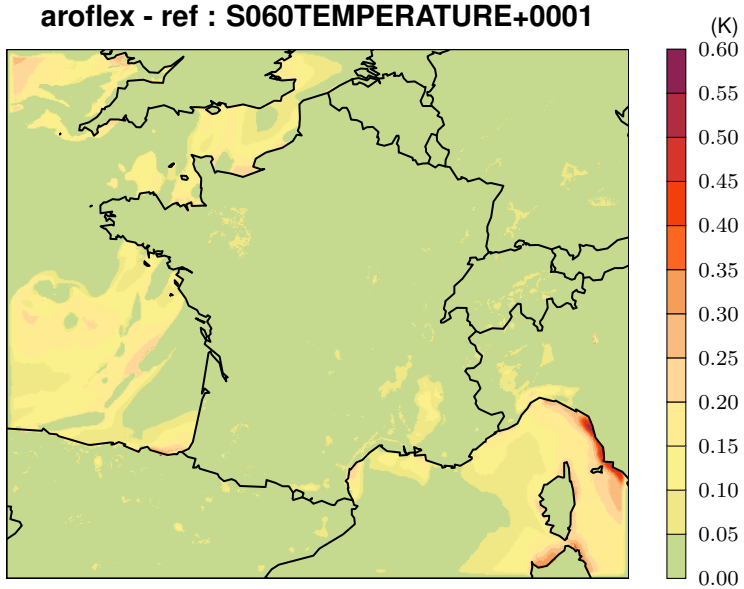


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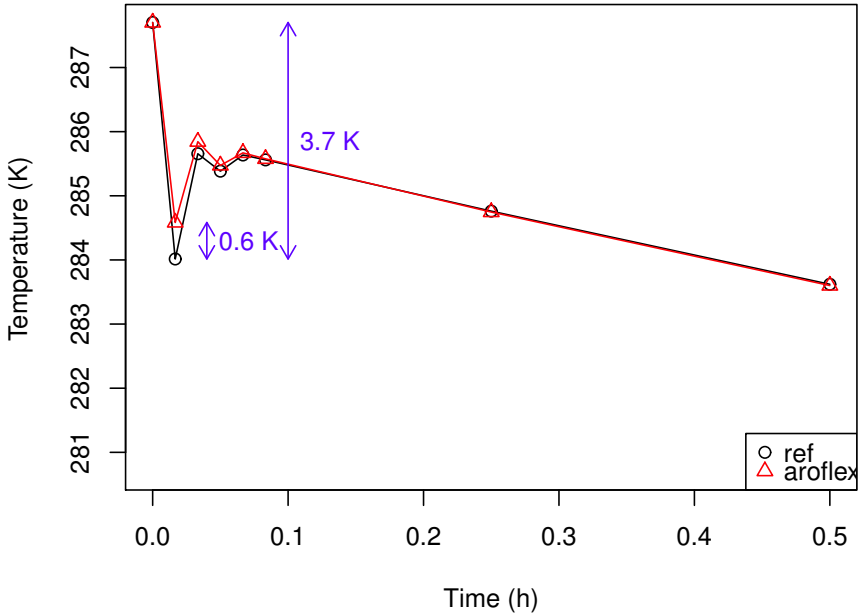


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- Anyway, the primary goal of this work is to have a common physics-dynamics interface to allow for the exchange of scientific ideas.

# The APLPAR routine

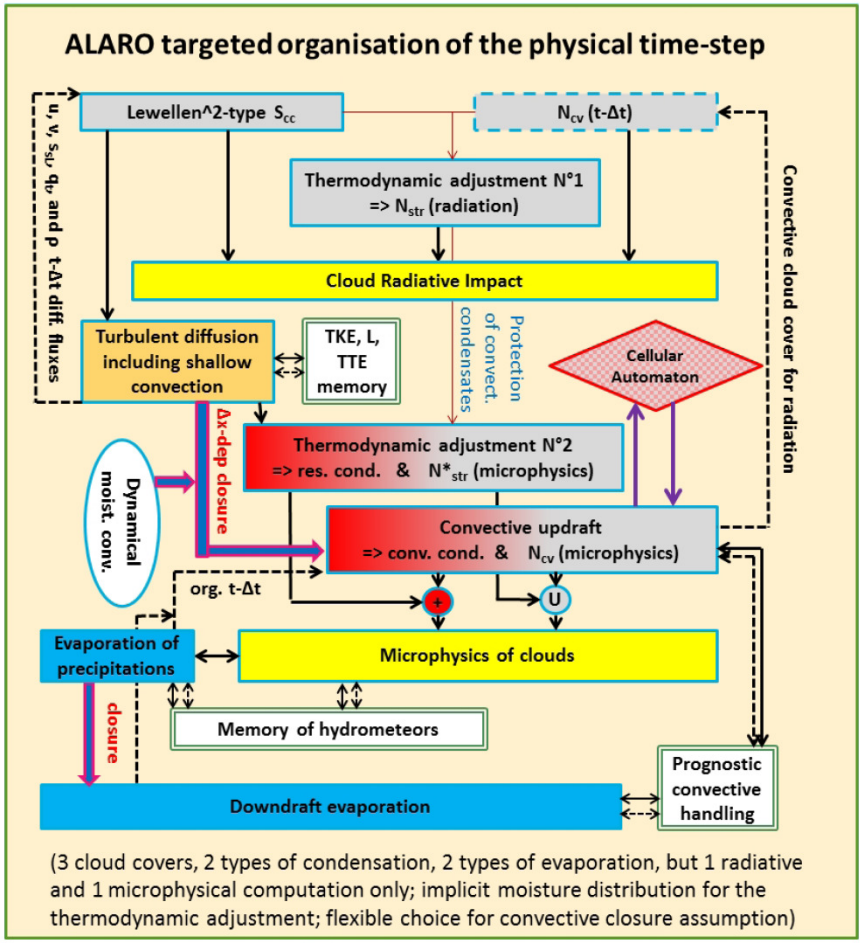


- The flexible physics-dynamics interface paves the road for a uniform treatment of the effect of parameterizations on the prognostic variables.
- But what about the inter-parameterization dependencies?
- If we want to cross-use (parts of) parameterizations between ARPEGE/ALARO and AROME, some cleaning is necessary first.
- The APLPAR routine has become overly complex: 4500+ lines, 300 arguments, 150+ IF statements, ...

# The APLPAR routine



- ALARO data flow between parameterizations:




*(Courtesy of R. Brožková)*

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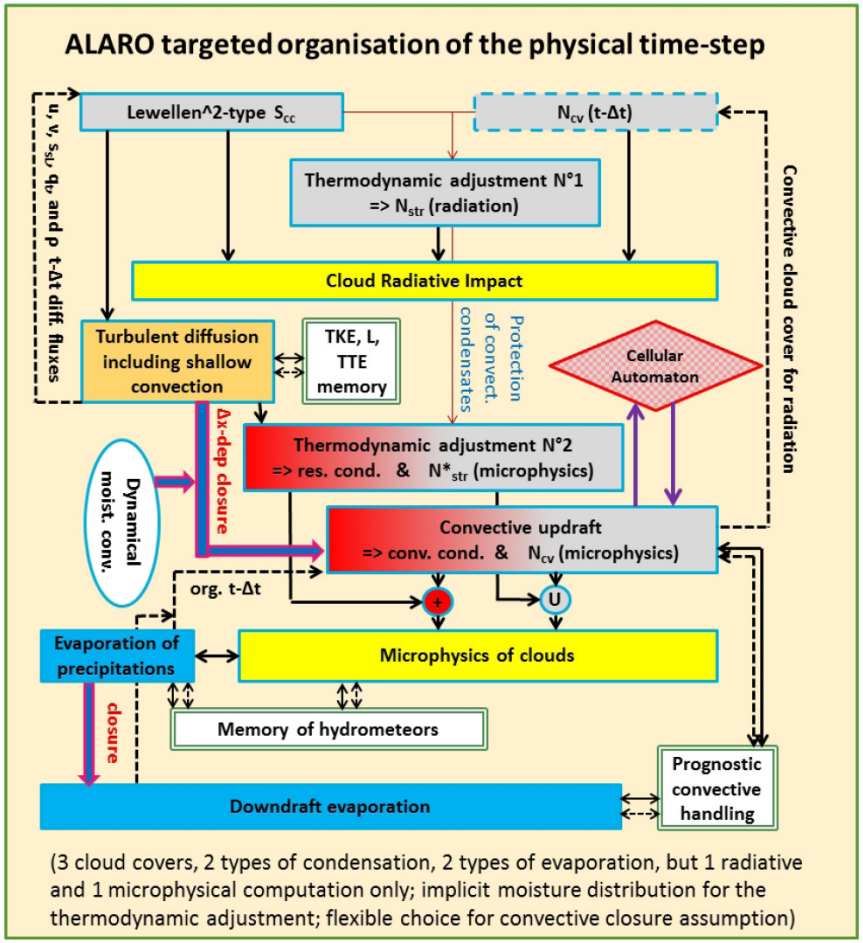


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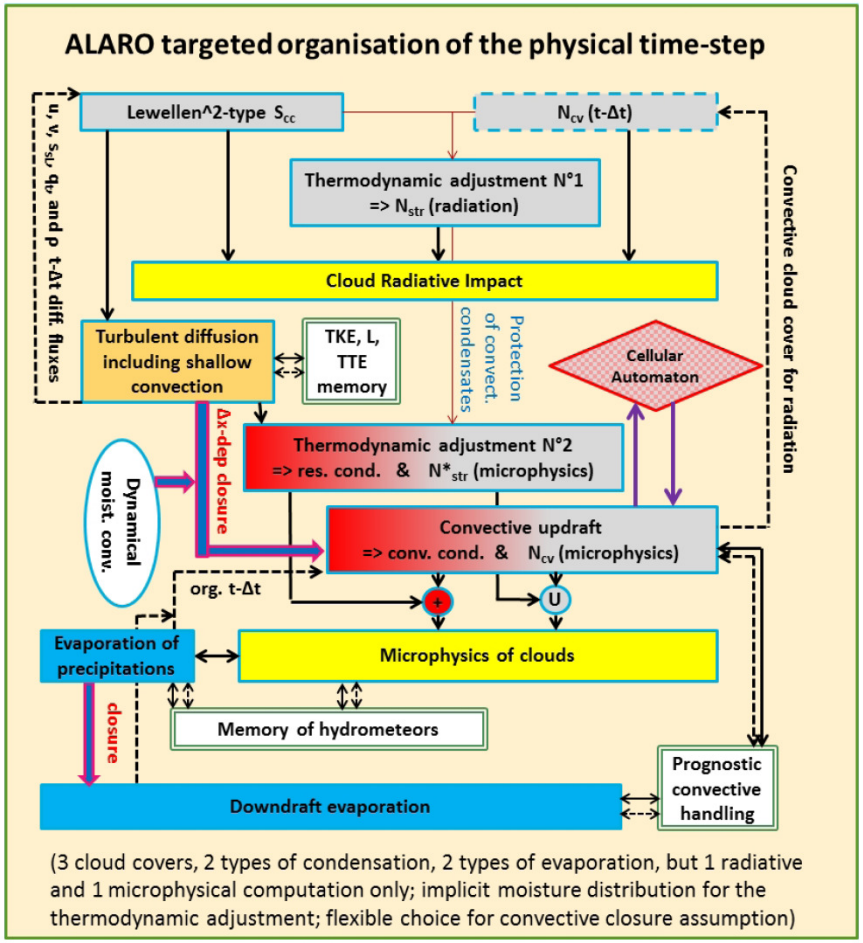


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- Try to identify well-defined blocks.

# APLPAR reorganization: radiation



- Started with streamlining radiation:
  - Hirlam radiation team working on comparison of different radiation schemes
  - feasibility case for other blocks
  - may provide some guidelines for cleaner physics
- Preparatory calculations were moved to separate subroutines:
  aerosols, cloudiness (?), ozone, co2, albedo
- Choice between different radiation schemes (FMR, acraneb) is moved to a separate routine.
- This clarifies dependencies between radiation and other parameterizations.
- About 600 lines of code were removed from APLPAR.
- Symmetric organization in APL_AROME is possible.

# APLPAR reorganization: some guidelines



- Removal of calculations from APLPAR!
- Fluxes/tendencies of prognostic variables with INTFLEX structures
- Diagnostics with DDHFLEX structures
- Clear purpose of variables
  - diagnostic variables
  - fluxes/tendencies with effect on prognostic variables
  - auxiliary variables between parameterizations
- Avoidance of global variables
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## Remarks

- Reorganization should not go at the expense of efficiency!
- Similar actions for OpenIFS and OOPS.

# Conclusions and work ahead



- Common flexible physics-dynamics interface has been coded.
- Its scientific performance needs to be tested further for AROME.
- Future developments (new fluxes, new hydrometeors) can benefit from it.

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- Future developments (new fluxes, new hydrometeors) can benefit from it.
- Physics calling routines (APLPAR and APL_AROME) cleaning and reorganization is challenging but necessary.
- We should aim (at least) at a ‘symmetric’ organization of these two routines.
- Feasibility has been proven for radiation.
- Next ‘block’ is turbulence and shallow convection.

# Conclusions and work ahead



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- Future developments (new fluxes, new hydrometeors) can benefit from it.
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- We should aim (at least) at a ‘symmetric’ organization of these two routines.
- Feasibility has been proven for radiation.
- Next ‘block’ is turbulence and shallow convection.
- Open question: what level of granularity are we aiming at when organizing APLPAR and APL_AROME in blocks?
- Finish work on DDHFLEX and remove old-style diagnostics.

# Thank you !