

**ALARO-1 Working Days  
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**Convergence actions on  
the physics-dynamics interface**

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Summary

- The physics-dynamics interface couples the physics parameterizations to the dynamical core.
- At this moment, AROME uses an interface that is different from the one used by ARPEGE/ALARO.
- This divergence hinders collaboration
  - ⇒ **convergence actions:**
    - ◆ harmonization between different models
    - ◆ increase flexibility regarding interface input, number and type of water species, ...

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- Aspects of the physics-dynamics that are considered:
  - ◆ The slow sedimentation of cloud species
  - ◆ The interface input variables
  - ◆ The correction of negative humidities
  - ◆ Treatment of the kinetic energy in the enthalpy equation
- At this time, nonhydrostatism and its consequences are not considered

- Water species are transported by advection (precipitation) or diffusion (turbulence).
- Modeling sedimentation of suspended species (cloud water droplets and cloud ice particles) as a combined advective/diffusive process is not a very good idea:
  - ◆ The distinction between advection and diffusion is a matter of scale.
  - ◆ Due to the vertical staggering, the sedimentation speed cannot be determined unambiguously from the flux.
  - ◆ A strict distinction between precipitating and suspended species is consistent with the impact of the  $\delta_m$  switch on the interface equations (see later).
- The slow sedimentation can be modeled with an enhanced diffusive flux. This comes down to neglecting the influence of these terms in the kinetic energy.

⇒

Water species will be considered to be *either* suspended ( $q_v, q_l, q_i$ ) or precipitating ( $q_r, q_s, q_g, \dots$ )

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- The interface should be capable to treat an arbitrary number of water species.
- The contribution of local processes to specific humidities can be described with
  - ◆ pseudo-fluxes: currently used in ALARO
  - ◆ tendencies: currently used in AROME

The aim is to develop a harmonized interface that accepts pseudo-fluxes and tendencies.

- Besides the pseudo-fluxes/tendencies, the interface also needs the absolute precipitation fluxes and diffusive fluxes at all vertical levels.
- Compactness or detail?

Equations for a mixed pseudo-fluxes/tendencies interface with an arbitrary number of water species:

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Equations for a mixed pseudo-fluxes/tendencies interface with an arbitrary number of water species:

- Transform absolute fluxes into relative (w.r.t. the barycenter) fluxes:

$$P_k = P_k^* - q_k \sum_{j=0}^n P_j^* \quad \text{for } k = 0, \dots, n$$

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- Introduce the  $\delta_m$  switch as follows:

$$P_k^\delta = \begin{cases} \delta_m P_k & \text{for suspended species} \\ P_k & \text{for precipitating species} \end{cases}$$



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- The water species tendencies are given by

$$\frac{\partial q_k}{\partial t} = \underbrace{-g \frac{\partial}{\partial p} [P_k^\delta + J_k]}_{\text{transport}} \quad \underbrace{-g \frac{\partial}{\partial p} \left[ \sum_{i \in \mathcal{F}} \sum_{j=1}^n P_{kj}^i \right]}_{\text{pseudo-fluxes}} \quad \underbrace{+ \sum_{i \in \mathcal{T}} \frac{\partial q_k^i}{\partial t}}_{\text{tendencies}}$$

where  $\mathcal{T}$  and  $\mathcal{F}$  represent the sets of processes returning tendencies and pseudo-fluxes, respectively.

- The enthalpy tendency equation is given by

$$\begin{aligned}
 \frac{\partial}{\partial t} (c_p T) = & -g \frac{\partial}{\partial p} \left[ \sum_{k=1}^n (c_k - c_{pd}) T P_k^\delta \right] && \text{(transport)} \\
 & -g \frac{\partial}{\partial p} [J_s + J_{rad}] && \text{(heat diffusion + radiation)} \\
 & + \sum_{i \in \mathcal{T}} \sum_{k=1}^n L_{kv}(T_0) \frac{\partial q_k^i}{\partial t} && \text{(tendencies)} \\
 & -g \frac{\partial}{\partial p} \left[ \sum_{i \in \mathcal{F}} \sum_{k=1}^n \sum_{j=k+1}^n L_{kj}(T_0) P_{kj}^i \right] && \text{(pseudo-fluxes)}
 \end{aligned}$$

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- Notes:

- ◆ The physics parameterizations cannot provide temperature tendencies directly because of the nonlinear character of  $c_p T$ . This is in contrast with the AROME philosophy.
- ◆ For AROME,  $J_k$  and  $J_s$  may need to be inferred from the total tendencies  $\partial q_k / \partial t$  and  $\partial T / \partial t$ .

- A flexible organization of the interface is required to allow the user to freely choose and combine physical packages.

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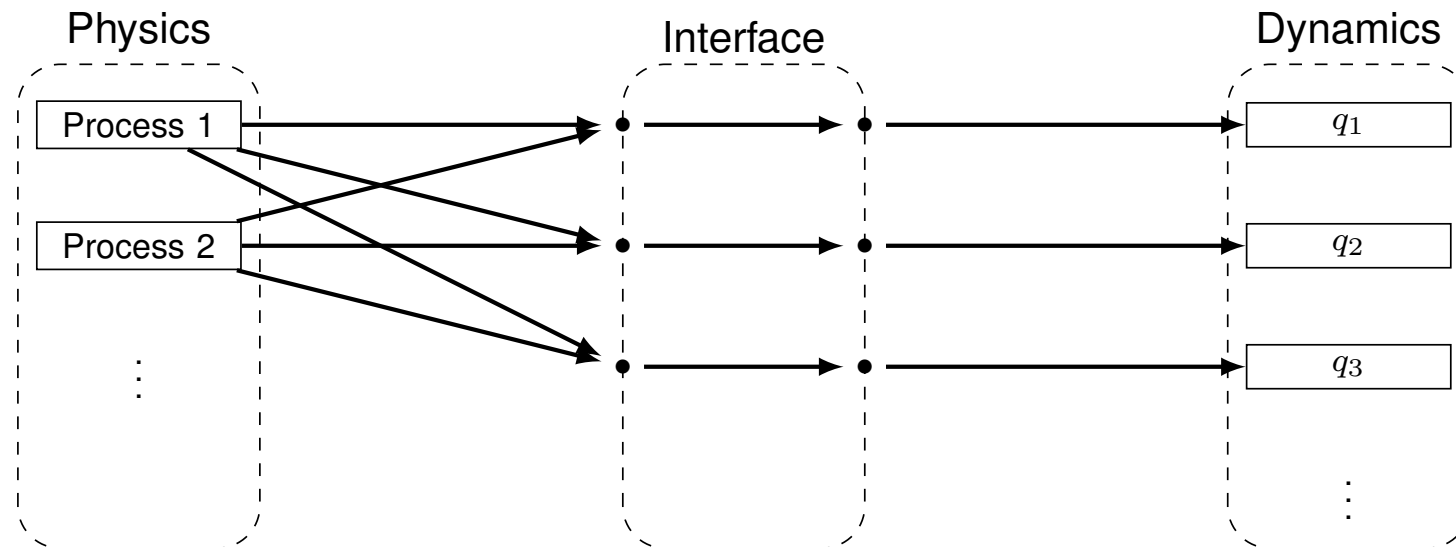
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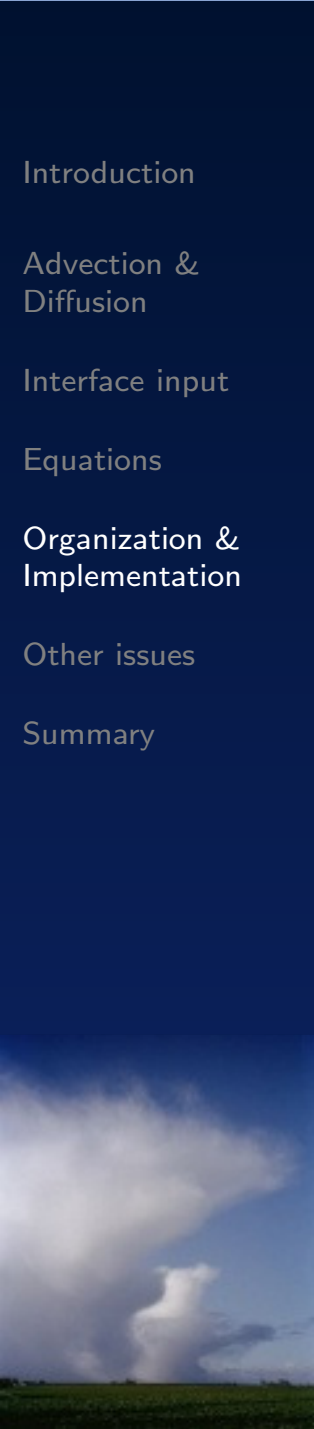
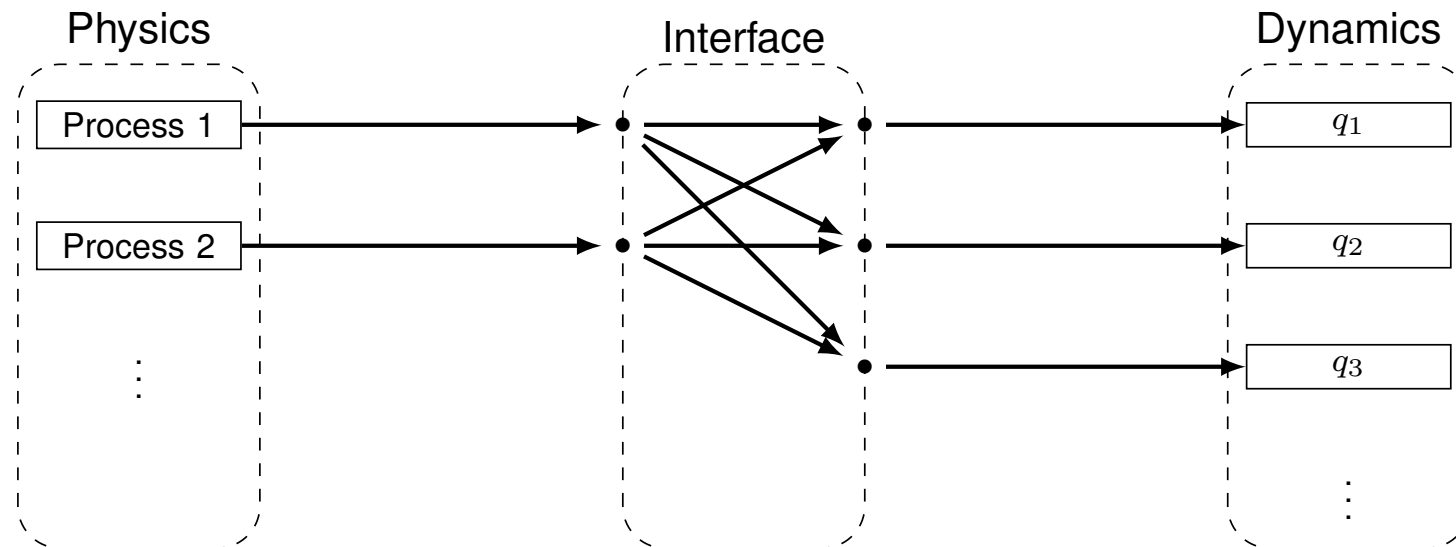
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- It could be interesting to switch the focus of the interface from *species*-based to *process*-based.

## Species-based



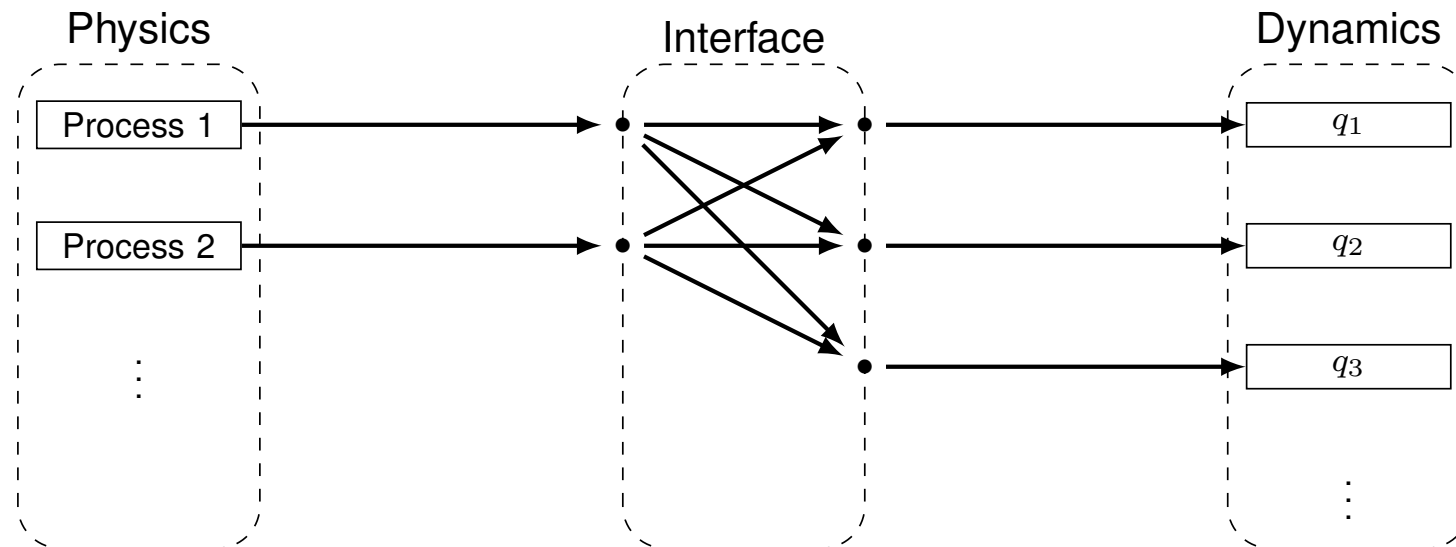
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## Process-based



- A flexible organization of the interface is required to allow the user to freely choose and combine physical packages.
- It could be interesting to switch the focus of the interface from *species*-based to *process*-based.

## Process-based



- Advantages:
  - ◆ increased flexibility w.r.t. process selection
  - ◆ increased flexibility w.r.t. number of water species
  - ◆ interface input is highly conform to diagnostics input

- Process-based interface requires possibility to transfer metadata along with variables
- This is achieved with Fortran derived data types
- Two-level implementation:
  - ◆ INTFIELD: very similar to DDHFLEX structure.
 

CNAME	identification of the field
CFLUX	the type of the field: precipitation flux, pseudo-flux, tendency or variable
CTARGET	target species of a pseudo-flux or a tendency
CSOURCE	source species of a pseudo-flux
RFIELD	pointer to an array containing the field values
LDDH	whether the field should be passed to DDH
  - ◆ INTPROC: group different INTFIELD structures that belong to the same process.
 

CPROC	identification of the process
NFIELD	number of fields belonging to this process
RFIELD	pointer to an array of INTFIELD structures



## Correction of negative humidities

- One can adopt two strategies:
  - ◆ consider them as a part of the physics (i.e. current situation)
  - ◆ consider them as a task of the interface, such that the same method can be used for different physics packages
- Should the corrective fluxes be (fully) included in the thermodynamic equation?

## Kinetic energy treatment

- include the kinetic energy change in the thermodynamic equation?
- attribute the kinetic energy change to the macroscopic kinetic energy or to the TKE
- transfer the full change of the TKE to the enthalpy equation, or only the dissipation term of the pTKE equation.

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Several propositions are made to harmonize and generalize the physics-dynamics interface:

- ◆ cope with tendencies or pseudo-fluxes
- ◆ consider an arbitrary number of water species
- ◆ account for slow sedimentation of cloud species
- ◆ flexibility with process-based organization
- ◆ unification of negative humidities correction
- ◆ include different treatments of kinetic energy