Recent development in DDH

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Outlook

1. A short overview of DDH
2. DDH in AROME

Introduction

- Model output:
  - Prognostic variables
- DDH:
  - Horizontal average of
    - Prognostic variables
    - Contributions of individual processes (turbulence, microphysical processes, radiation, pressure gradient force, …)

Analysis

- DDH is based on model equations in flux form

$$\frac{\partial}{\partial t}\left(\chi\frac{\partial p}{\partial \eta}\right) = -\nabla_\eta\cdot\left(\chi\mathbf{v}\frac{\partial p}{\partial \eta}\right) - \frac{\partial}{\partial \eta}\left(\chi\dot{\eta}\frac{\partial p}{\partial \eta}\right) + S_d\frac{\partial p}{\partial \eta} - g\frac{\partial F_\varphi}{\partial \eta} - gS_\varphi\frac{\partial G_\varphi}{\partial \eta}$$

(1) (2) (3) (4) (5)

7. Horizontal divergence
8. Vertical divergence
9. Adiabatic source (pressure gradient force,…)
10. Divergence of physical fluxes (turbulence, microphysics, …)
11. Tendencies due to physical parameterizations

No physical tendencies!

Analysis *(cont.)*

$$\chi : 1, \vec{v}, q_{v,}\ q_l, q_n, k, c_p T, \overrightarrow{M}, s$$

(k : kinetic energy; s : entropy; $\overrightarrow{M}$: angular momentum)

Vertical discretization of conservation equation:

$$\frac{\partial}{\partial t}(\chi \delta p) = -\nabla_\eta \cdot (\chi \mathbf{V} \delta p) - \delta\left(\chi \dot{\eta} \frac{\partial p}{\partial \eta}\right) + S_d \delta p - g \delta F_\varphi - g S_\varphi \delta G_\varphi$$

$$\delta \xi_l = \xi_{\bar{l}} - \xi_{\bar{l}-1}$$

Averaging

Horizontal average

$$\frac{\partial}{\partial t}\left(\overline{\chi\frac{\partial p}{\partial \eta}}^{H}\right)=-\nabla_\eta\cdot\left(\overline{\chi\mathbf{v}\frac{\partial p}{\partial \eta}}^{H}\right)-\frac{\partial}{\partial \eta}\left(\overline{\chi\dot{\eta}\frac{\partial p}{\partial \eta}}^{H}\right)+\overline{S_d\frac{\partial p}{\partial \eta}}^{H}-g\frac{\partial \overline{F_\varphi}^{H}}{\partial \eta}-gS_\varphi\frac{\partial G_\varphi}{\partial \eta}$$

Time average

$$\overline{\chi\frac{\partial p}{\partial \eta}}^{H}\Bigg|_{t=n\cdot\Delta t}-\overline{\chi\frac{\partial p}{\partial \eta}}^{H}\Bigg|_{t=0}=$$

$$=-\nabla_\eta\cdot\left(\overline{\overline{\chi\mathbf{v}\frac{\partial p}{\partial \eta}}^{H}}^{t}\right)-\frac{\partial}{\partial \eta}\left(\overline{\overline{\chi\dot{\eta}\frac{\partial p}{\partial \eta}}^{H}}^{t}\right)+\overline{\overline{S_d\frac{\partial p}{\partial \eta}}^{H}}^{t}-g\frac{\partial \overline{\overline{F_\varphi}^{H}}^{t}}{\partial \eta}-gS_\varphi\frac{\partial \overline{G_\varphi}^{t}}{\partial \eta}$$

Values under averaging operators are saved in DDH output files.

Classification of terms in DDH

1. Variables: $\frac{1}{g}\chi\delta p$
2. Dynamical tendencies: $\frac{\delta t}{g}\nabla_\eta\cdot(\chi\mathbf{V}\delta p)$ and $\frac{\delta t}{g}S_d\delta p$
3. Dynamical fluxes: $\frac{\delta t}{g}\chi\dot{\eta}\frac{\partial p}{\partial\eta}$
4. Physical fluxes: $\delta t\cdot F_\varphi$
5. Physical tendencies: $gS_\varphi\delta G_\varphi$

Full levels: variables and tendencies

Half levels: fluxes

Horizontal domains

- Global
- Zonal band
- User defined
  - Point:
    - mesh point (i,j); domain type=1
    - geographic (λ,φ) ; domain type=4
  - Quadrangle
    - geographic coordinates of all points; domain type=2
  - Rectangle
    - geographic coordinates of two points; domain type=3

Output files

Format: lfi

Name:

- Global domain: DHFGLeeee+nnnn
- Zonal bands: DHFZOeeee+nnnn
- User defined: DHFDLeeee+nnnn

eeee: experiment name

nnnn: ouput time

Output files, content

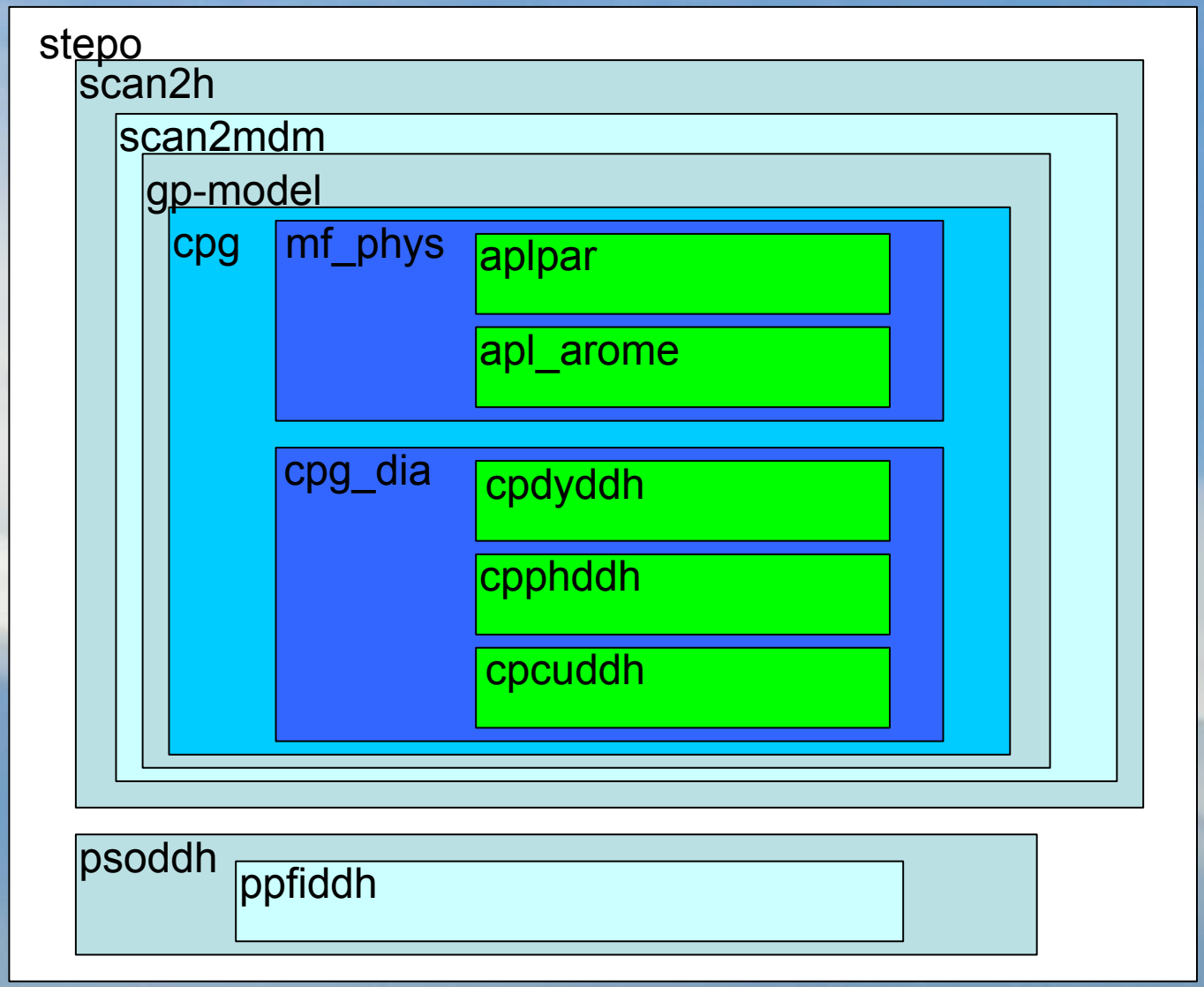
Descriptions:

date, output time, number of output values, number of levels, logical keys, numbers describing data, descriptions of domains, …

Data:

- variables at time 0 and t
- Dynamical tendencies
- Dynamical fluxes
- Physical fluxes
- Physical tendencies

Position in the code



Putting new terms in DDH (old)

1. In SUNDDH: adjust ‘pointers’

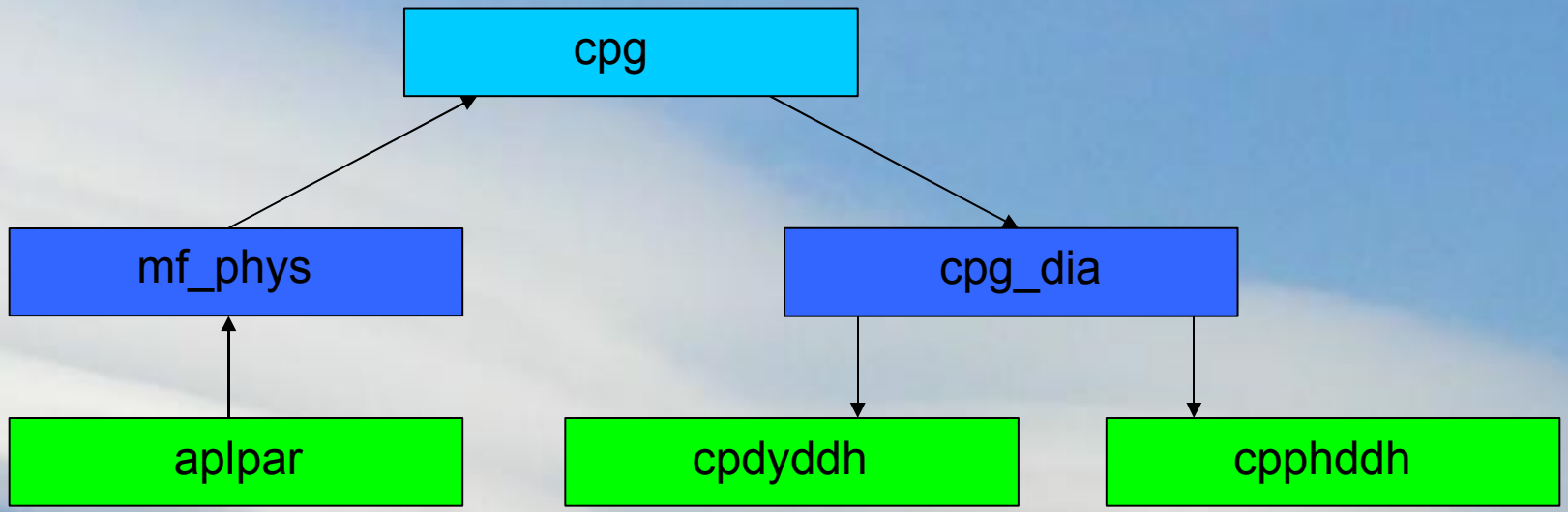
2. In CPDYDDH (variables and dynamical tendencies and fluxes) and CPPHDDH (physical fluxes and tendencies), for each new term, add line:

```
PCHCV(JROF,JLEV,IDHCV+n+1)= new term
```

3. In PPFIDH, for each new term, add:

```
WRITE(CLMON,5000) KNUM,’type’,’variable’,’desctiption’
CALL LFIECR(ICOREP,NPODDH,CLNOM,PDDHCV(0/1, IDHCV+n+1,lenght)
```

Data flow for physical fluxes ARPEGE/ALADIN



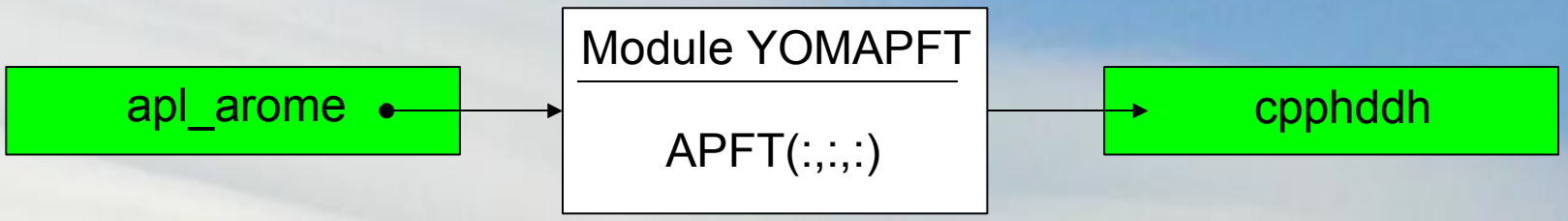
Module YOMAPFT

```
TYPE TYPE _APFT
  CHARACTER (LEN=1) : CFT
  CHARACTER (LEN=2) : CVAR
  CHARACTER(LEN=10): CNANE
END TYPE TYPE _APFT
```

```
TYPE(TYPE _APFT) :: YAPFT(:)
```

```
REAL(KIND=JPRB) :: APFT(:,:,:)
```

Data flow for physical fluxes AROME



Some changes in DDH subroutines

CPPHDDH

A loop is added doing assignement:

PCHCV(JROF,JLEV,JPROC)= APFT(JROF,JLEV,JPROC)

PPFIDH

A loop is added doing assignement:

WRITE(CLMON,5000) KNUM, YAPFT(:)% CFT, YAPFT(:)%CVAR, YAPFT(:)%CNAME

CALL LFIECR(ICOREP,NPODDH,CLNOM,PDDHCV(0/1, IDHCV+n+1,length)

Putting new terms in DDH (new)

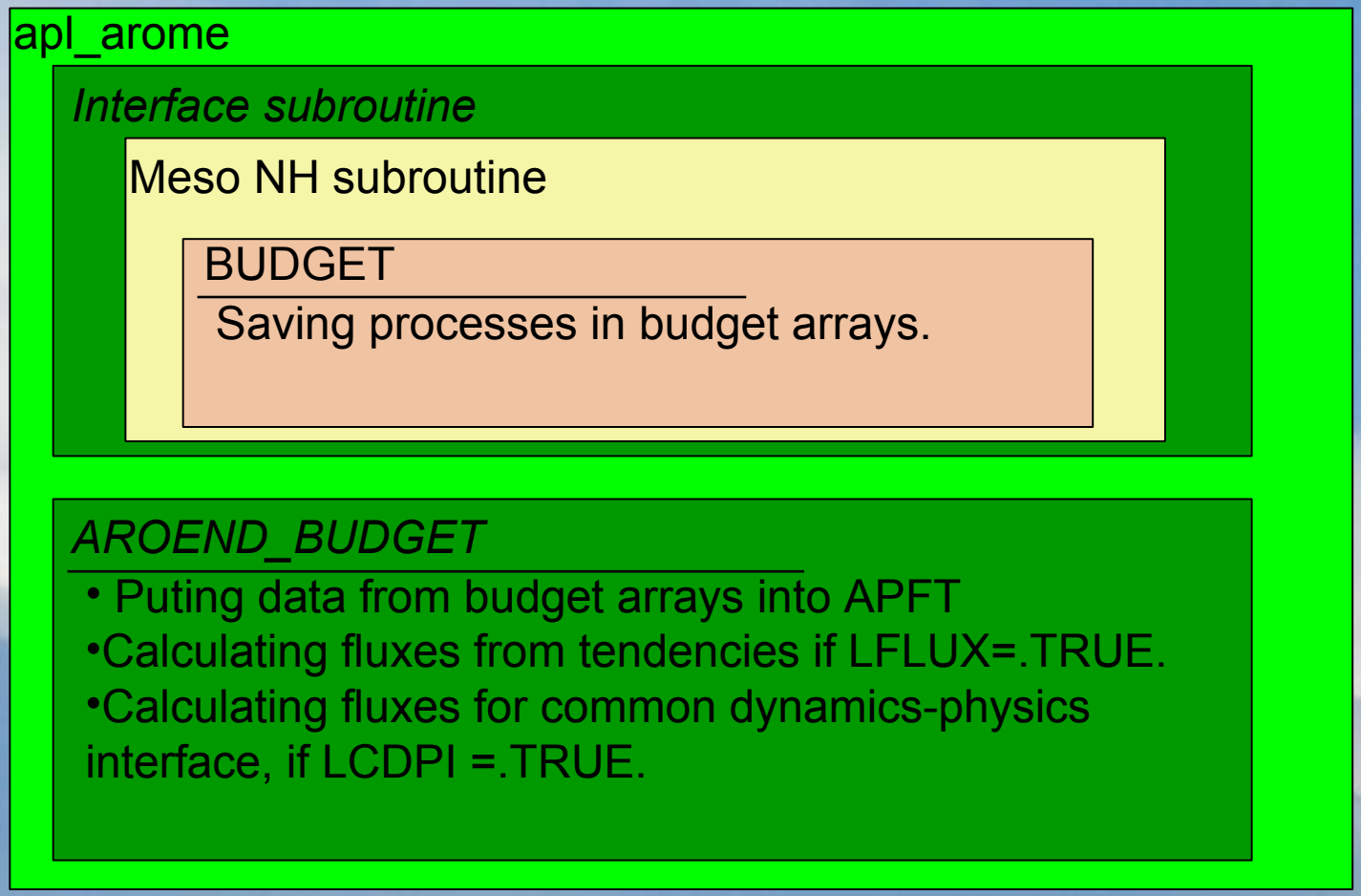
1. In SUNDDH: adjust ‘pointers’

2. In CPDYDDH (variables and dynamical tendencies and fluxes) , add line:

   PCHCV(JROF,JLEV,IDHCV+n+1)= *new term*

3. In ARO_INIAPFT, for each new term, add:
   - description in YAPFT
   - rise the number of terms for one
   - adjust some “pointers”

Subroutine APL_AROME



Namelists

```
&NAMDDH
  LHDDOP = .TRUE.,
  LHDHKS = .TRUE.,
  LHDMCI = .FALSE.,
  LHDENT = .FALSE.,
  LHDPRG = .FALSE.,
  LHDPRZ = .FALSE.,
  LHDPRD = .FALSE.,
  LHDEFG = .FALSE.,
  LHDEFZ = .FALSE.,
  LHDEFD = .TRUE.,
  LHDLIST = .TRUE.,
  LONLYVAR = .FALSE.,
  LHDORIGP = .TRUE.,
  LHDCDPI =  .TRUE.,
  NDHZPR = 0,
  NDHKD = 0,
  BDEDDH( 1,1)= 3.,
  BDEDDH( 2,1)= 1.,
  BDEDDH( 3,1)= 2.5755
  BDEDDH( 4,1)=44.5423,
```

```
&NAMCT0
  NFRCO=180,
   NFRDHFD=1,
   NDHFDTS(0)=10,
   NDHFDTS(1)= 90,
   NDHFDTS(2)= 93,
   NDHFDTS(3)= 96,
   NDHFDTS(4)= 99,
   NDHFDTS(5)= 102,
   NDHFDTS(6)= 105,
   NDHFDTS(7)= 108,
   NDHFDTS(8)= 111,
   NDHFDTS(9)= 114,

NDHFDTS(10)=117,
```

```
&NAMOPH
   LINC=.FALSE.,

&NAMPHY
   LPHCDPI= .FALSE.

&NAMARPHY
   LBUFLUX=.TRUE.
```