Implementation of SURFEX in ARPEGE/ALADIN

(physical interface part)

Progress, current status and remaining issues

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Overview

- SURFEX – externalized surface model
- SURFEX can be run independently from the atmospheric model – off-line mode, and as a part of atm. model – on-line mode
- Interface between the surface and the atmosphere is implemented by a limited number of surface fluxes, and small number of surface variables
- The interface is comprised of a call to a single subroutine in physical calculation (in APLPAR)
- Coupling can be implicit and explicit
- Implicit coupling needed for coupling with ARPEGE/ALADIN due to the long time step ($\geq$ 480 s up to 1800 s)

Technical overview

- Phasing of code from CY 25 to CY 29 SCM was needed (APLPAR, ACDIFV1, ACDIFV2, ACHMTLS)
- After phasing to CY 29 SCM and testing, the code is phased to CY 30T1 3D model
- The implementation in ARPEGE/ALADIN benefited from the previous work done for AROME
- Initialization procedures developed for AROME are adopted and modified to fit ARPEGE/ALADIN
- SURFEX calling routine – ARO_GROUND_PARAM is adopted from AROME and modified

Implicit coupling

- Needed to assure numerical stability for long time steps occurring in ALADIN/ARPEGE
- Implemented according to the paper by Best et al. (2004)
- Implicit coupling developed in climate group on CY 25 SCM
- Surface fluxes calculated in the middle between downward and upward sweep of vertical diffusion.
- Operational diffusion routine (ACDIFUS) is split in two parts (ACDIFV1 and ACDIFV2), and the call to SURFEX (ARO_GROUND_PARAM) is added in between

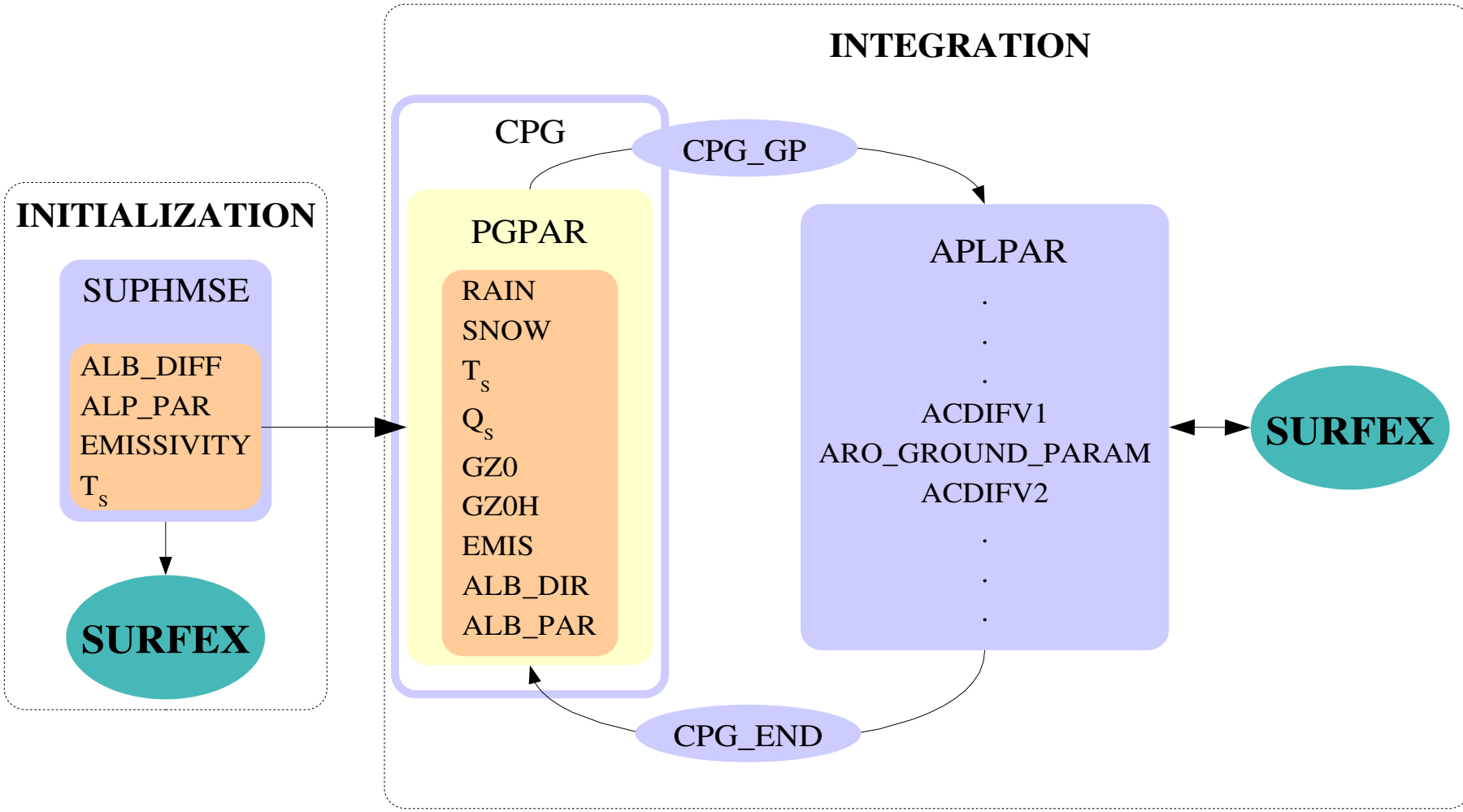
Enquiry mode

- Enquiry mode for SURFEX is developed in order to get the values of some variables without doing surface calculations
- Functionality is provided by GET_FLUX_n and GET_SURF_VARS_n subroutine
- The variables that can be enquired are:
  - Surface fluxes, radiative temperature, albedos
  - air temperature and humidity at 2m, fractions of sea, water, nature, town , surface humidity over water, sea, nature, town, snow fraction over vegetation and ground, surface and thermal roughness lengths

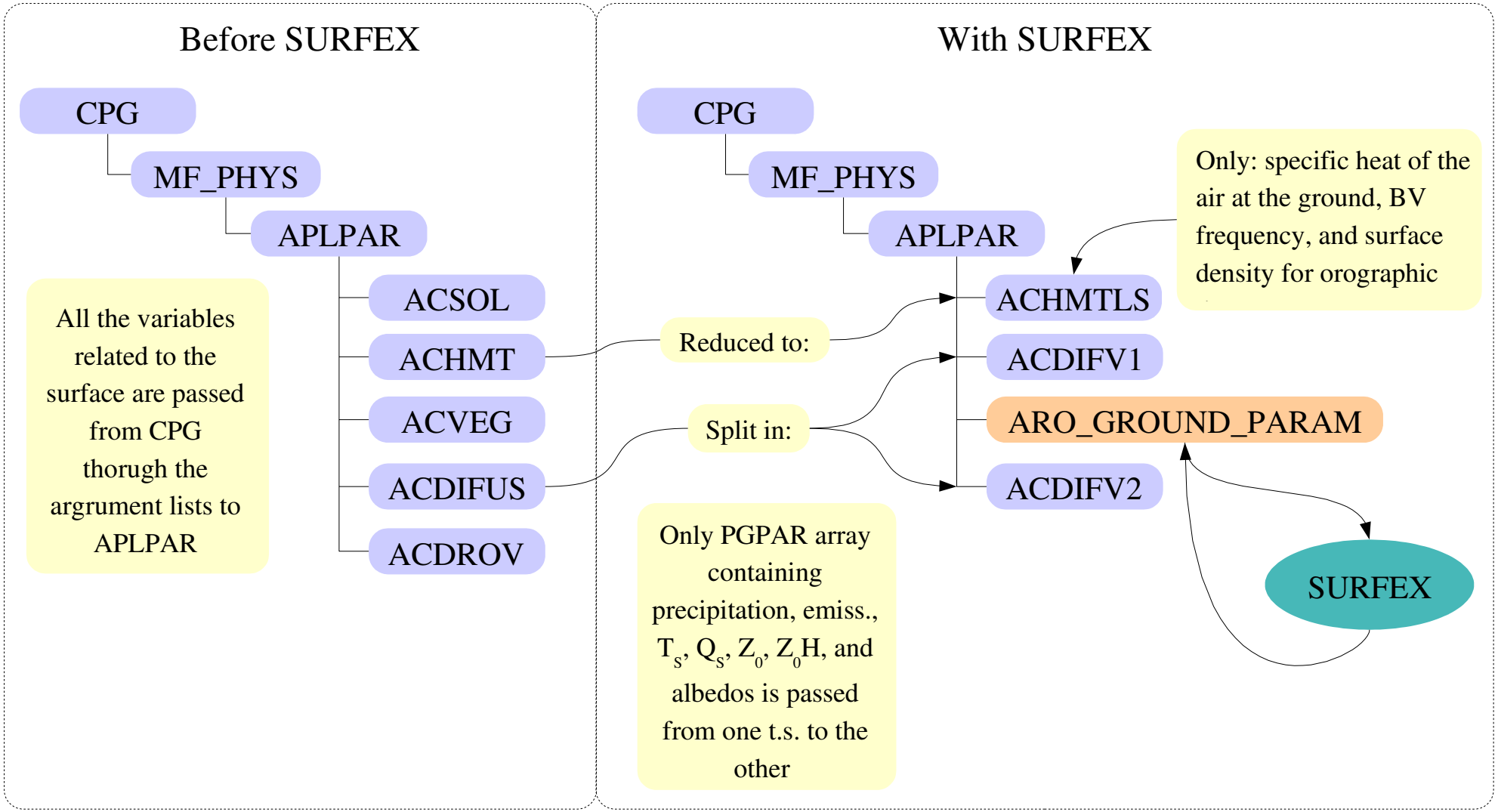
Implementation in 3D model

- We benefited from the work done for AROME
- Initialization of SURFEX is separated from the initialization of AROME (new SUPHMSE subroutine added)
- The same SURFEX initialization procedure used for AROME and ARPEGE/ALADIN
- Emissivity, surface radiative temperature, surface specific humidity are passes from one time step to the other
- CPG_GP and CPG_END are modified to save pseudo historical fields (PGPAR)
- APLPAR of 3D model is modified, and ACDIFV1 and ACDIFV2 are phased to CY30T1
- The effort to make SURFEX & ARPEGE/ALADIN work together is in progress - currently in a “bug hunting” phase

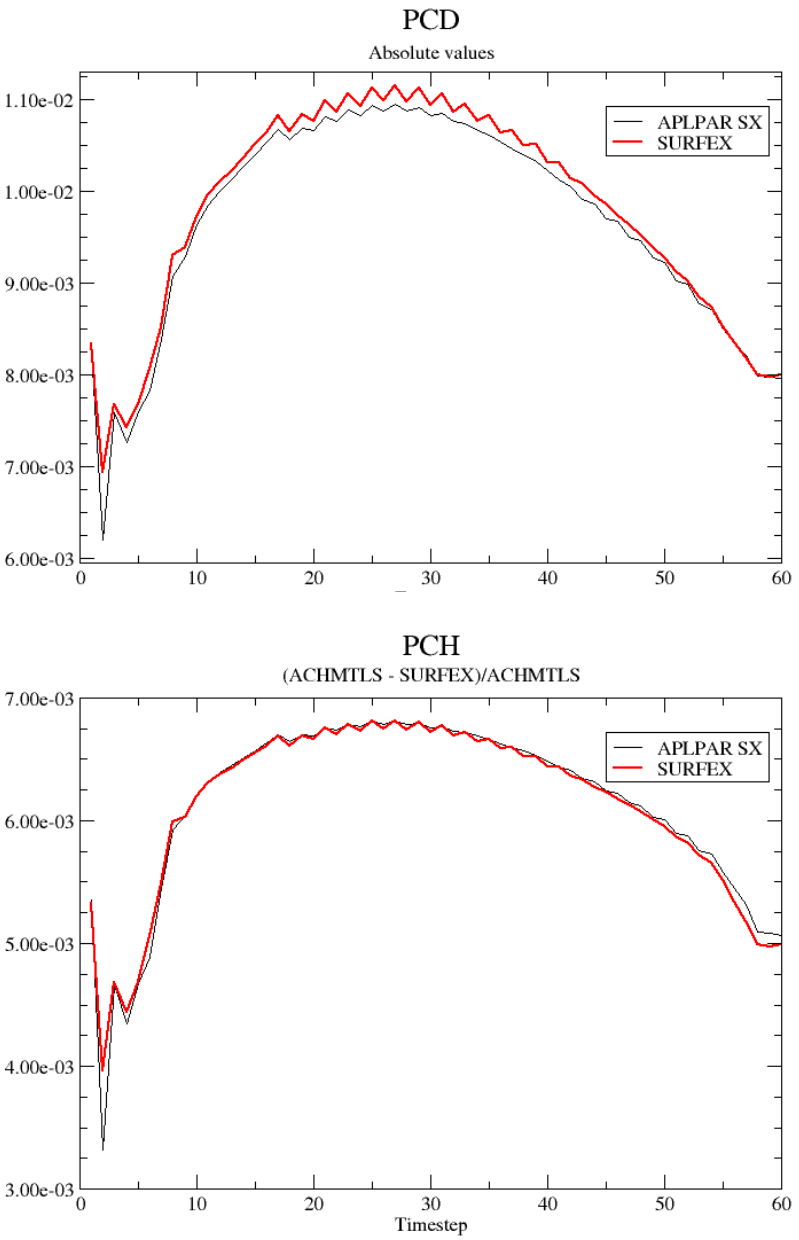
Implementation of SURFEX in 3D ARPEGE/ALADIN – data flow



Differences in implementation of the surface scheme with/without SURFEX



Turbulent exchange coefficients



TSTEP = 900 s

- Ex. coeff. calculated by ACHMTLS – thin black, SURFEX – red
- The greatest differences in the first 10 time steps
- In 2nd t.s. 12% for Cd and 19% for Ch
- Otherwise – differences are very small
  - Max 3% for Cd
  - Max 2% for Ch

Antifibrillation

- Solution proposed by Piet Termonia but:
- The solution assumes the existence of antifibrillation coefficients (PXDROV, PXHROV) modifies the calculus of implicit coupling coefficients
- Turbulent exch. coeff. are needed for calculation of antifibrillation coeffs
- Antifibrillation coefficients should be computed by SURFEX because the calculation of turb. ex. coefs in ARPEGE/ALADIN is in the contrast with the philosophy of externalization

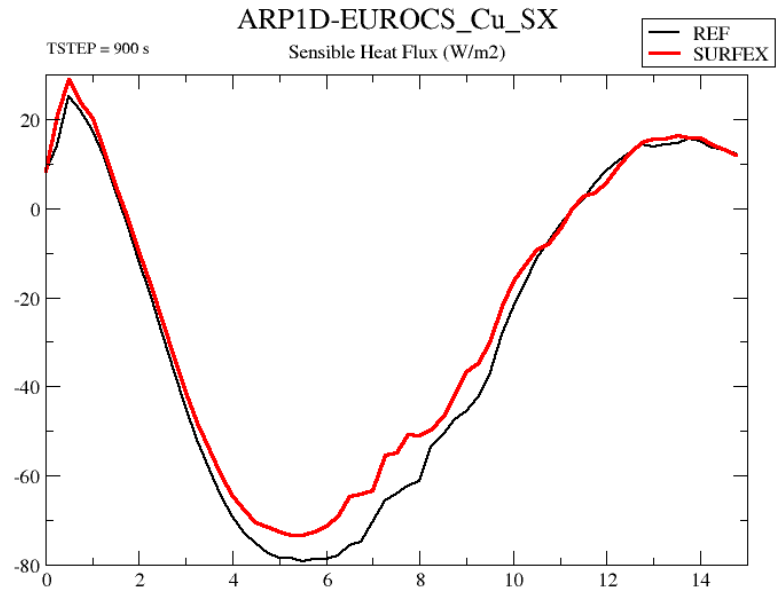
Antifibrillation - continued

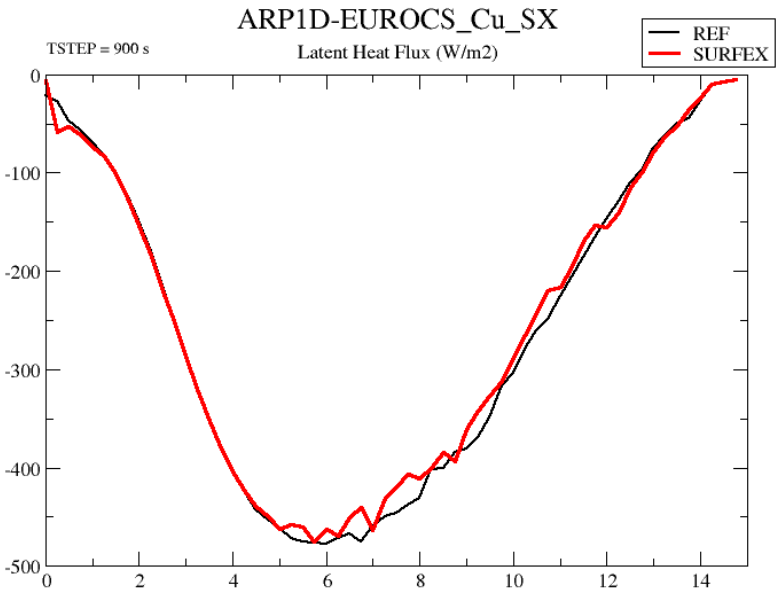
- The scheme is beneficial for the results but in the current situation breaks the spirit of externalization
- In order to use it, the antifibrillation coefficients or turbulent exchange coefficients should be provided by SURFEX

Antifibrillation – another approach

- Use the existing AF scheme
- Instead of computing surface AF coefficients – use AF coefficients from the lowest model level
- Not a clean solution but it works well

Results vegetation = 1 (1)



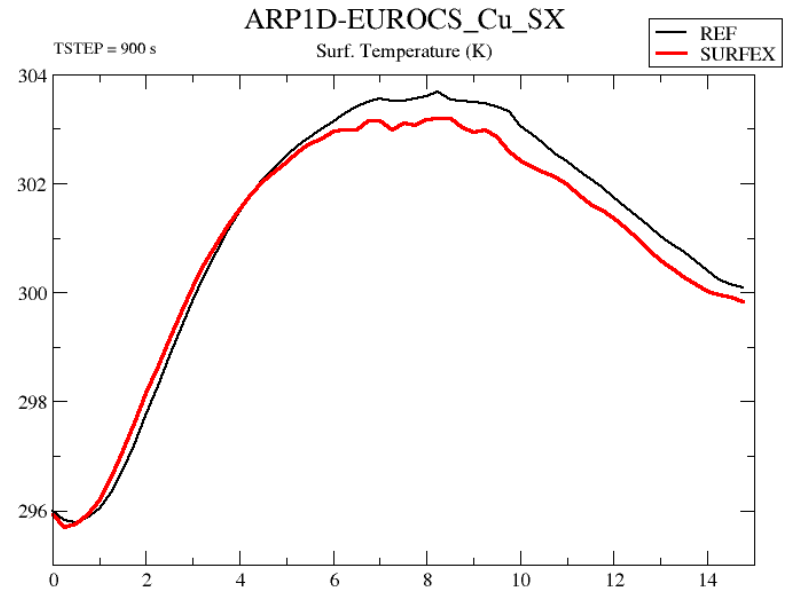


TSTEP = 900 s

- Sensible Heat Flux
- Differences < 8 W m^{-2}

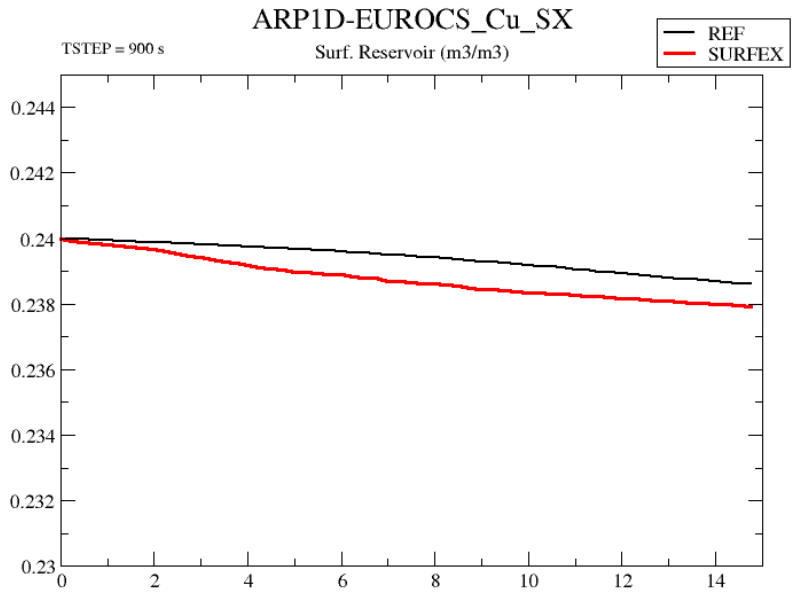
- Latent Heat Flux
- Differences < 40 W m^{-2}

Results vegetation = 1 (2)



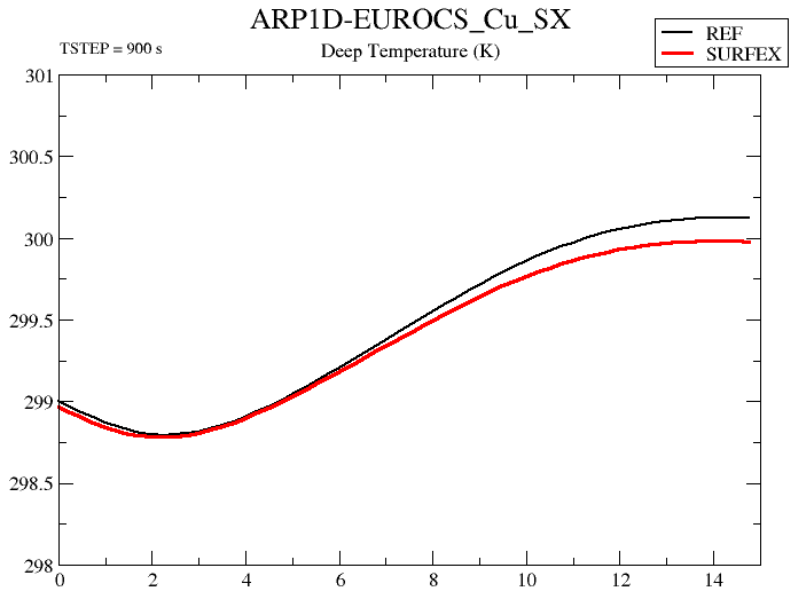
TSTEP = 900 s

- Surface temperature (K)
- Differences < 0.75 K



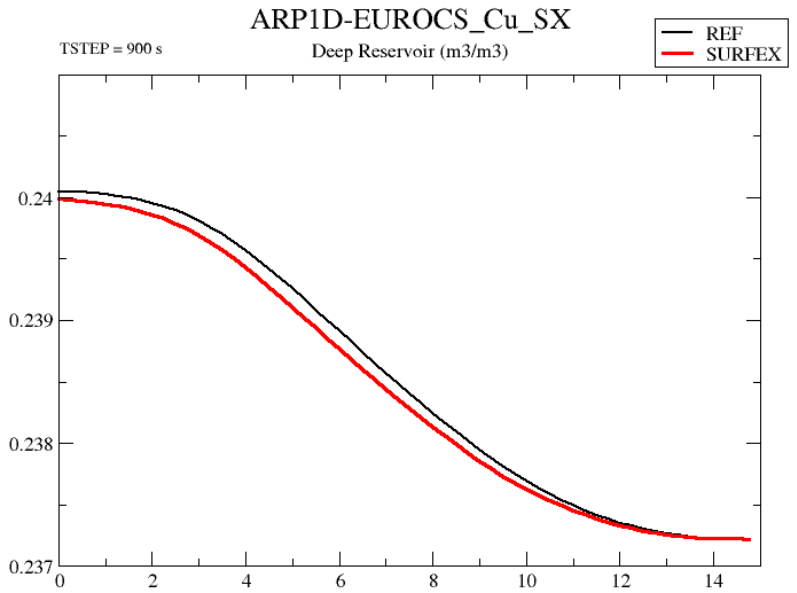
- Surface reservoir (m^3/m^3)
- Differences < 0.002 m^3/m^3

Results vegetation = 1 (3)



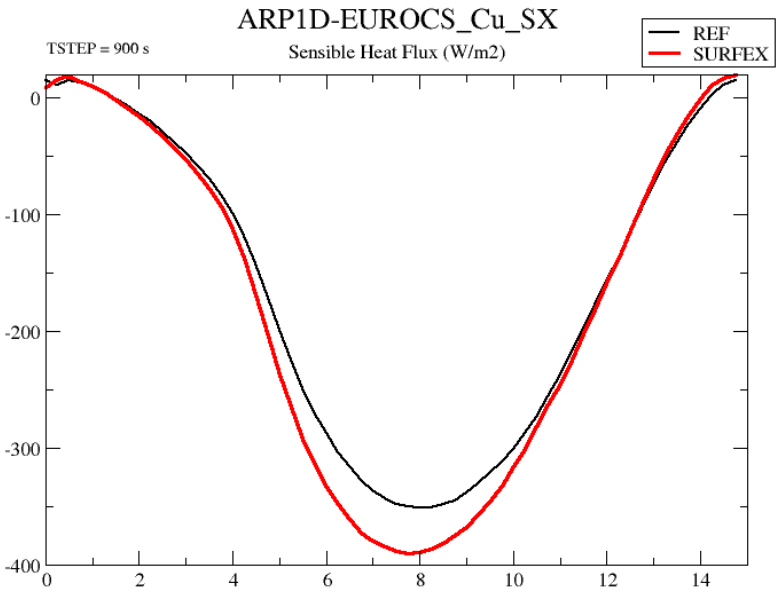
TSTEP = 900 s

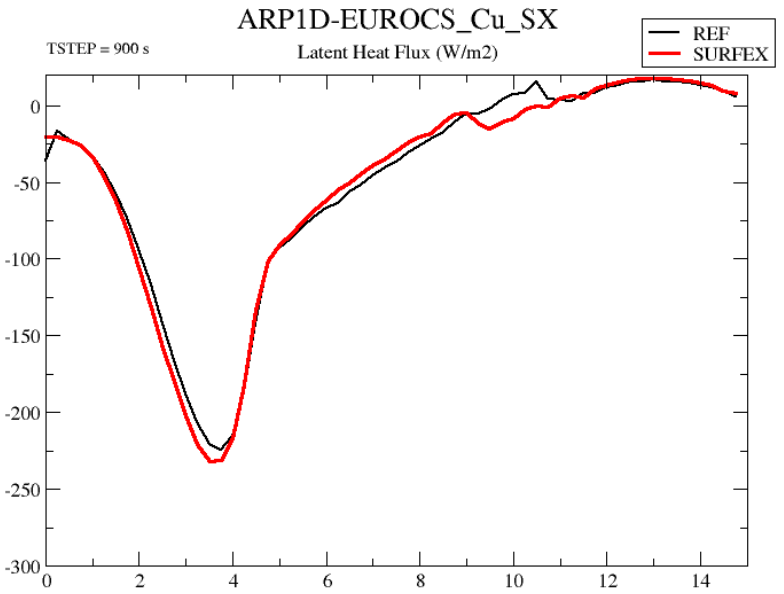
- Deep temperature (K)
- Differences < 0.2 K



- Deep reservoir (m^3/m^3)
- Differences < 0.0001 m^3/m^3

Results vegetation = 0 (1)



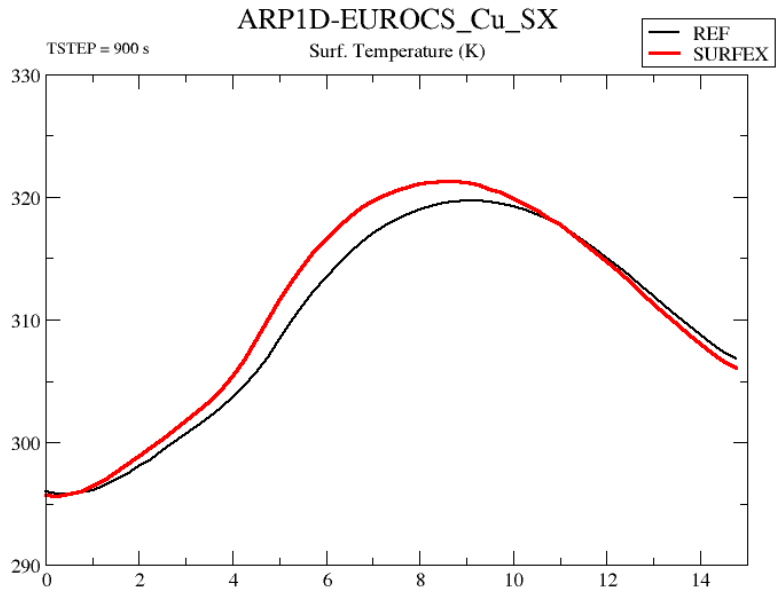


TSTEP = 900 s

- Sensible Heat Flux
- Differences < 40 W m^{-2}

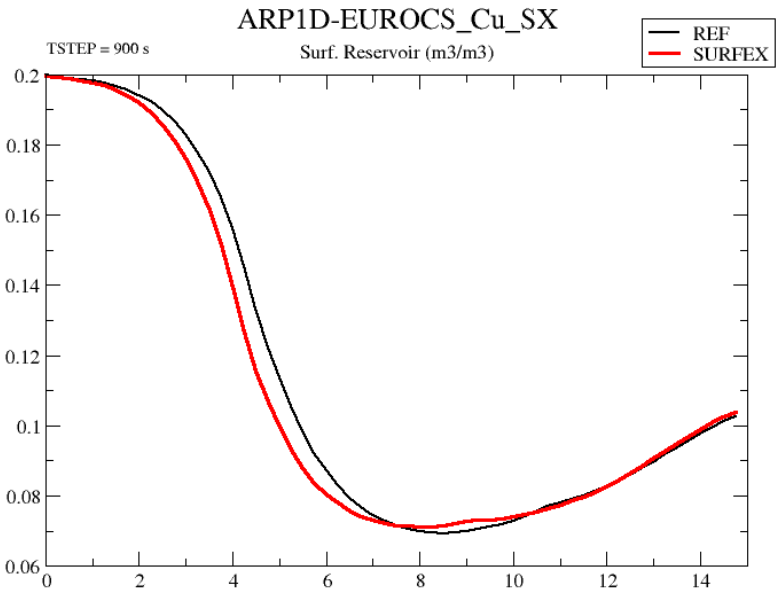
- Latent Heat Flux
- Differences < 20 W m^{-2}

Results vegetation = 0 (2)



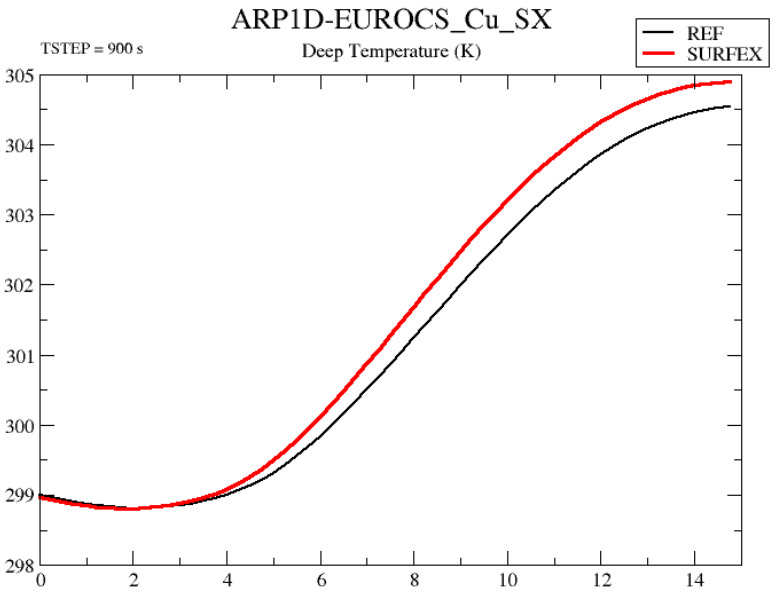
TSTEP = 900 s

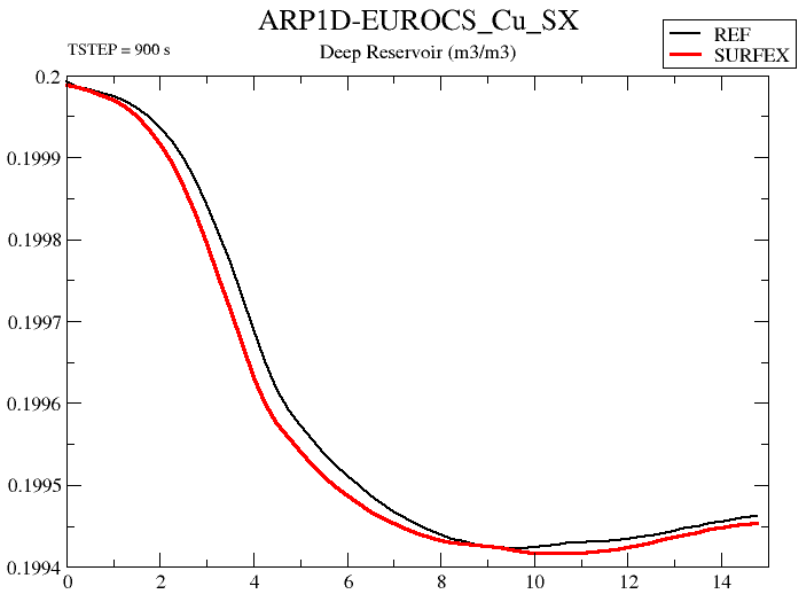
- Surface temperature (K)
- Differences < 1.5 K



- Surface reservoir (m^3/m^3)
- Differences < 0.02 m^3/m^3

Results vegetation = 0 (3)





TSTEP = 900 s

- Deep temperature (K)
- Differences < 0.5 K

- Deep reservoir (m^3/m^3)
- Differences < 0.00005 m^3/m^3

Conclusions

- 1D tests show that implicit coupling is well done and it is fit for 3D
- Technical obstacles for using SURFEX in ARPEGE/ALADIN – i.e. diagnostics of roughness lengths, surface humidity and fractions of snow, are solved
- The problem of initialization of SURFEX is solved thanks to the effort made by the AROME team to separate initialization of SURFEX from the initialization of AROME
- ARPEGE/ALADIN code is modified to include SURFEX but still there are critical bugs

Future

- Find and correct all bugs in ARPEGE/ALADIN – SURFEX interface
- Validation of SURFEX in 3D ARPEGE/ALADIN forecast
- Adaptation of surface and upper-air analysis to SURFEX

Thanks!