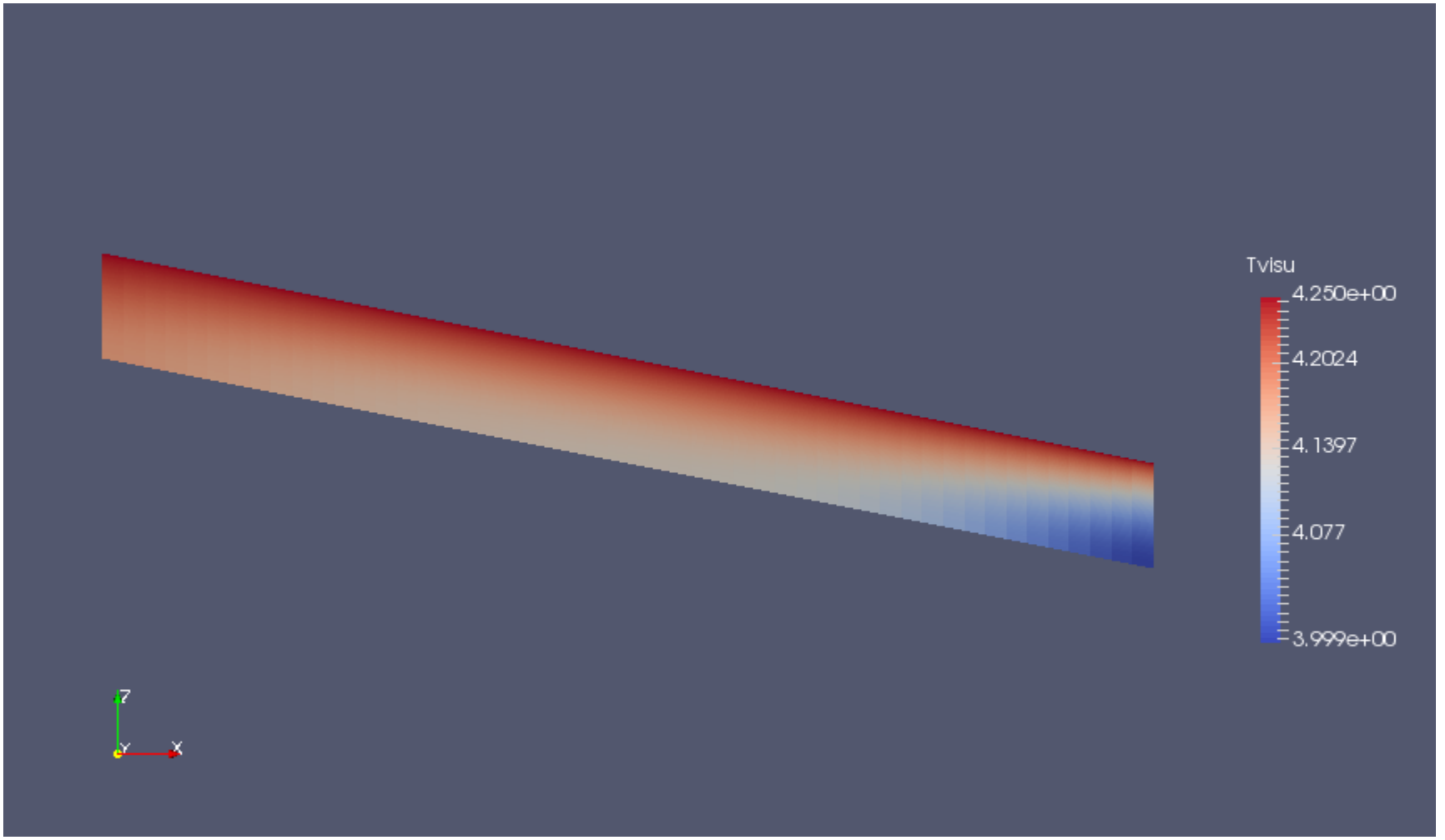
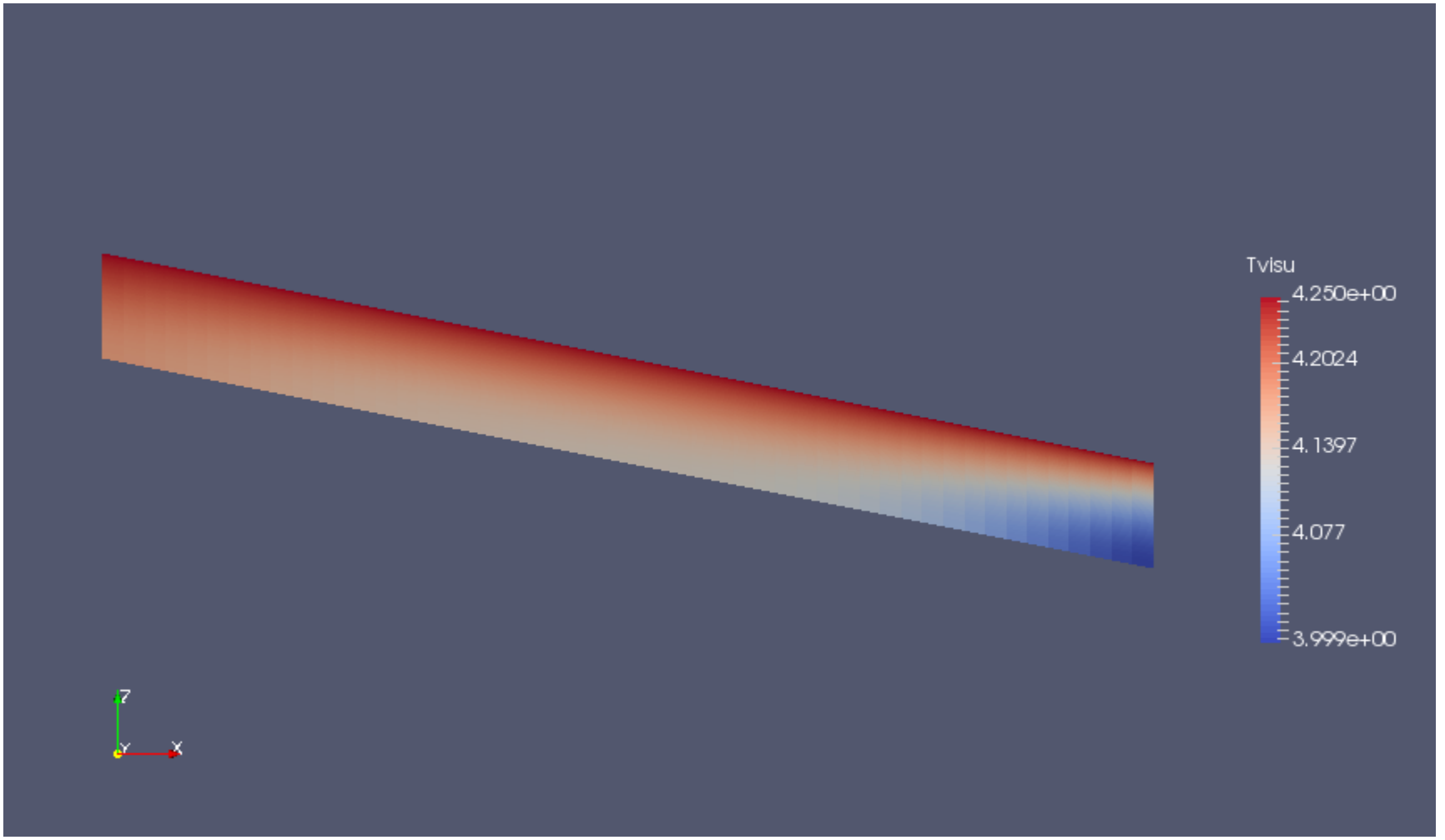
permaFoam_demoCase

Modelling a freeze/thaw annual cycle of an inclined loam bank with permaFoam



(see Orgogozo *et al.*, submitted to PPP for details on the permaFoam solver)

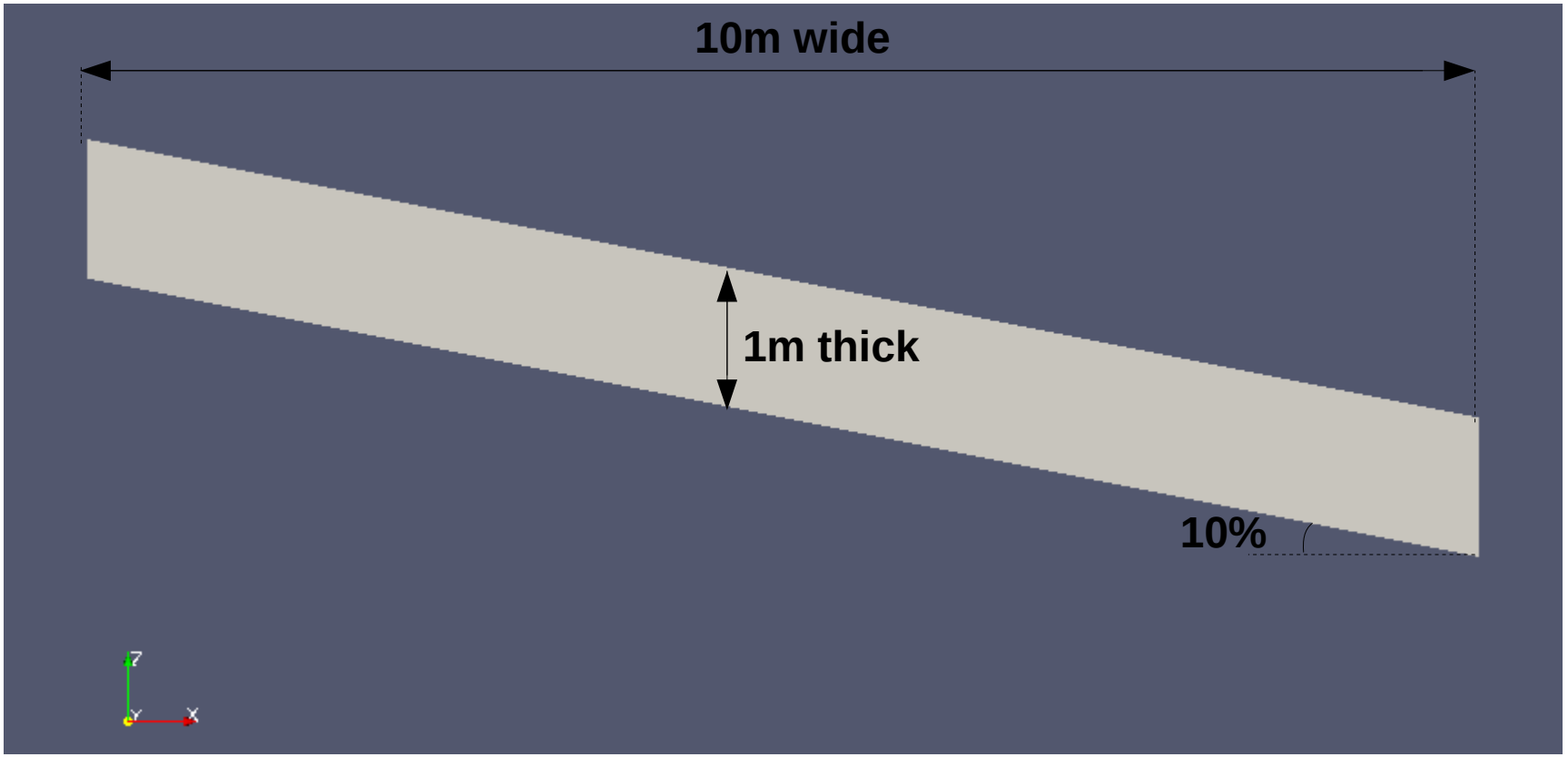
In order to illustrate the capabilities of permaFoam, we propose to model the thermo-hydrological behaviour of a partially water saturated loam bank along a schematic annual hydrological cycle. This document details the geometrical features, the initial conditions, the time varying forcings, the boundary conditions, and some results associated with this modelling.



This demonstration test case may also serve to validate your installation of the permaFoam package on your own computer.

Geometrical features and medium properties

The domain of modelling is a 2D bank of loam, with 10m of width, 1 m of thickness, and 10% of slope.



Geometrical features and medium properties

The domain of modelling is constituted of loamy soil. The considered hydrodynamic and thermal properties are the same that those which are used for describing the mineral horizon in the associated manuscript by Orgogozo *et al.* (submitted to PPP).

K_s [m.s^{-1}]	4.63 1e-7
α [m^{-1}]	0.82
n [-]	1.2179
θ_s [-]	0.412
θ_r [-]	0.01
θ_{WP}[-]	0.149
S [m^{-1}]	4.04 1e-5
$K_{T,\,soil}$ [kg.m.s^{-3}.K^{-1}]	2.9
$C_{T,\,soil}$ [kg.m^{-1}.s^{-2}.K^{-1}]	1.92 1e6
w [K]	0.93

Meteorological forcings

We consider a virtual and schematic cold climate, with an active season of 4 months and a cold season of 8 months. The meteorological forcings for each season are detailed below.

Active season

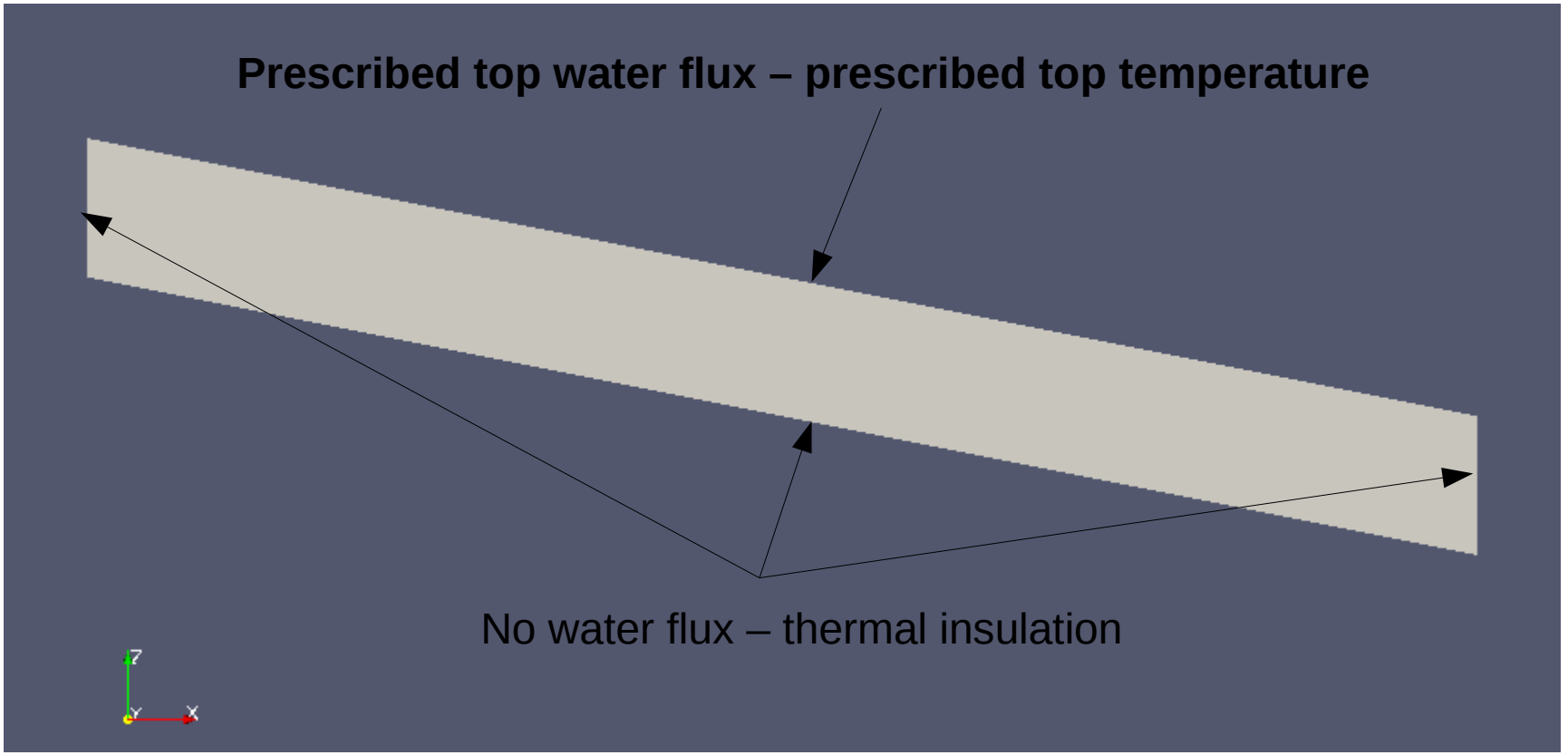
Top temperature: 4.25°C
Monthly top water flux: 48 mm/month (*i.e.* 1.85*1e^{-8} m.s^{-1})
Monthly potential evapotranspiration: 51.8 mm/month (homogeneously distributed in the bank)

Cold season

Top temperature: -4.75°C
Monthly top water flux: 0 mm/month
Monthly potential evapotranspiration: 0 mm/month

Boundary conditions

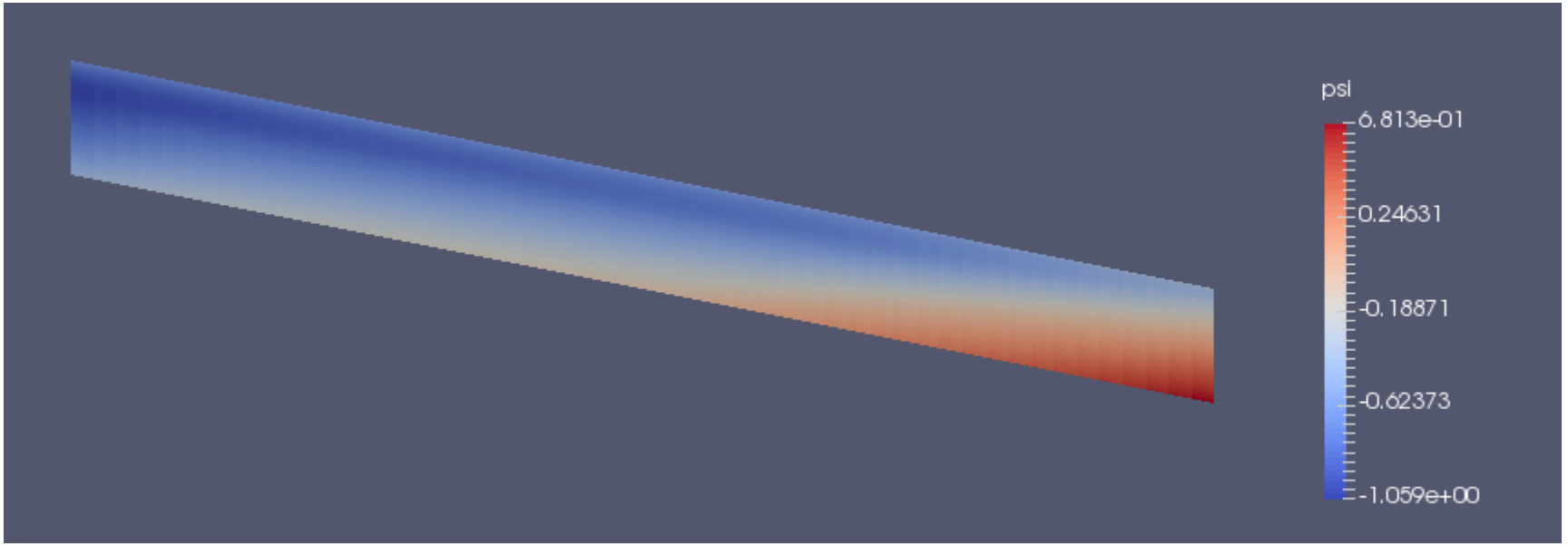
The domain is insulated and impermeable at all its boundaries except the top boundary. In this top boundary, the temperature is fixed, equal to the top temperature of the considered season (see previous slide). The water flux is also prescribed seasonally at this top boundary, with a peculiar feature: the fixed water flux boundary condition switch to a fixed pressure head (equal to 0m) whenever the porous medium become water saturated.



Initial conditions

The initial conditions had been computed by cycling several times the sequence active season/cold season until the steady state have been reached (*i.e.* until the values of the field at the end of the sequence active/season/cold season does not vary from one cycle to the next one).

The chosen initial instant is the beginning of the active season. At this moment, the temperature field within the loam bank is homogeneous, equal to the top temperature in cold season (-4.75°C), and the pressure head distribution is the following (psi, the water pressure head, in m):



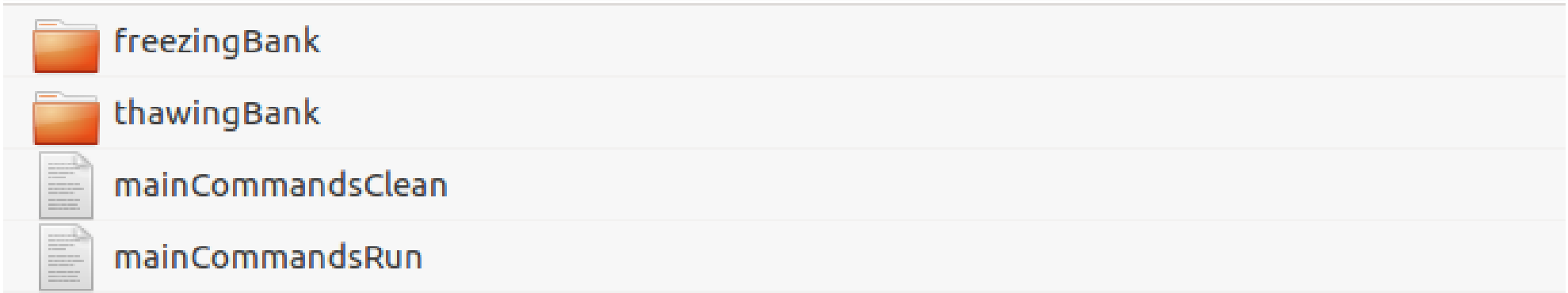
Structure of the permaFoam_demoCase

The permaFoam_demoCase is divided in 2 sub-cases: thawingBank and freezingBank.

thawingBank is the sub-case of the active season. Its initial conditions are those that are described in the previous slide.

freezingBank is the sub-case of the cold season. The initial conditions of the freezingBank sub-case are obtained by copying (mapping) the pressure head and temperature fields of the last time step of the thawingBank sub-case (once it has been ran) on the initial time step of the freezingBank sub-case. This is done using the mapFields OpenFOAM® utility.

MainCommandsRun contains all the commands that must be executed to run the whole permaFoam_demoCase, while mainCommandsClean contains all the commands needed to clean the case.



Run the permaFoam_demoCase

In order to run the permaFoam_demoCase, you need first to install OpenFOAM® v1712 and swak4foam (the development version is needed at the time of writing). See the readMe file of the permaFoam_package for more details.

Then copy the permaFoam_demoCase directory in the "run/" directory of your openfoam workspace, and execute the following command:

source mainCommandsRun

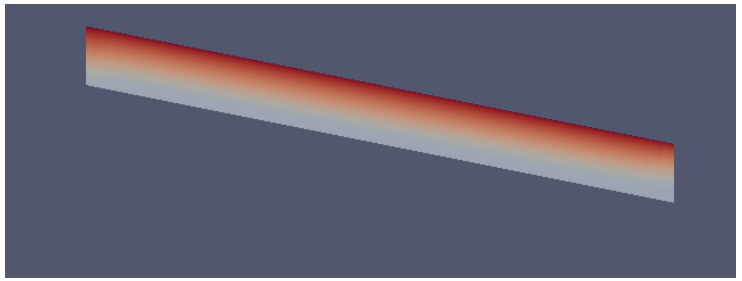
It will run the whole case. The computation time for the completion of the run of the thawingBank sub-case is of about 8mn*, and the run of the freezingBank sub-case last 2mn*. Overall, after roughly 10mn of waiting, you should be able to check the results of the permaFoam_demoCase.

*** used computer: processor Intel® CoreTM i7-6600U CPU @ 2.60GHz × 4, 15.6 Go of RAM, 64-bit Ubuntu 16.04 LTS linux distribution.**

Example of results of the permaFoam_demoCase

Active season

t = 0 days

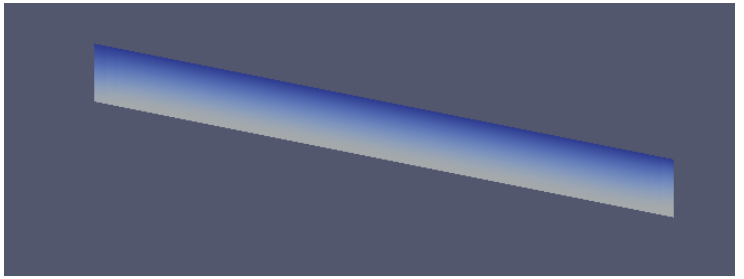


t = 60 days

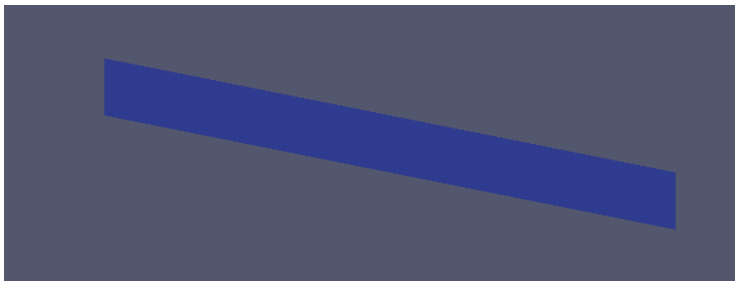
t = 120 days

Cold season

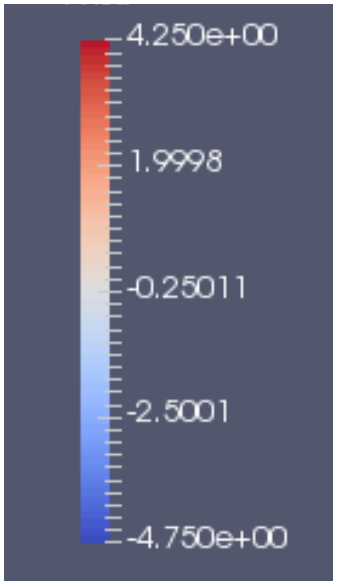
t = 120 days



t = 180 days



t = 240 days

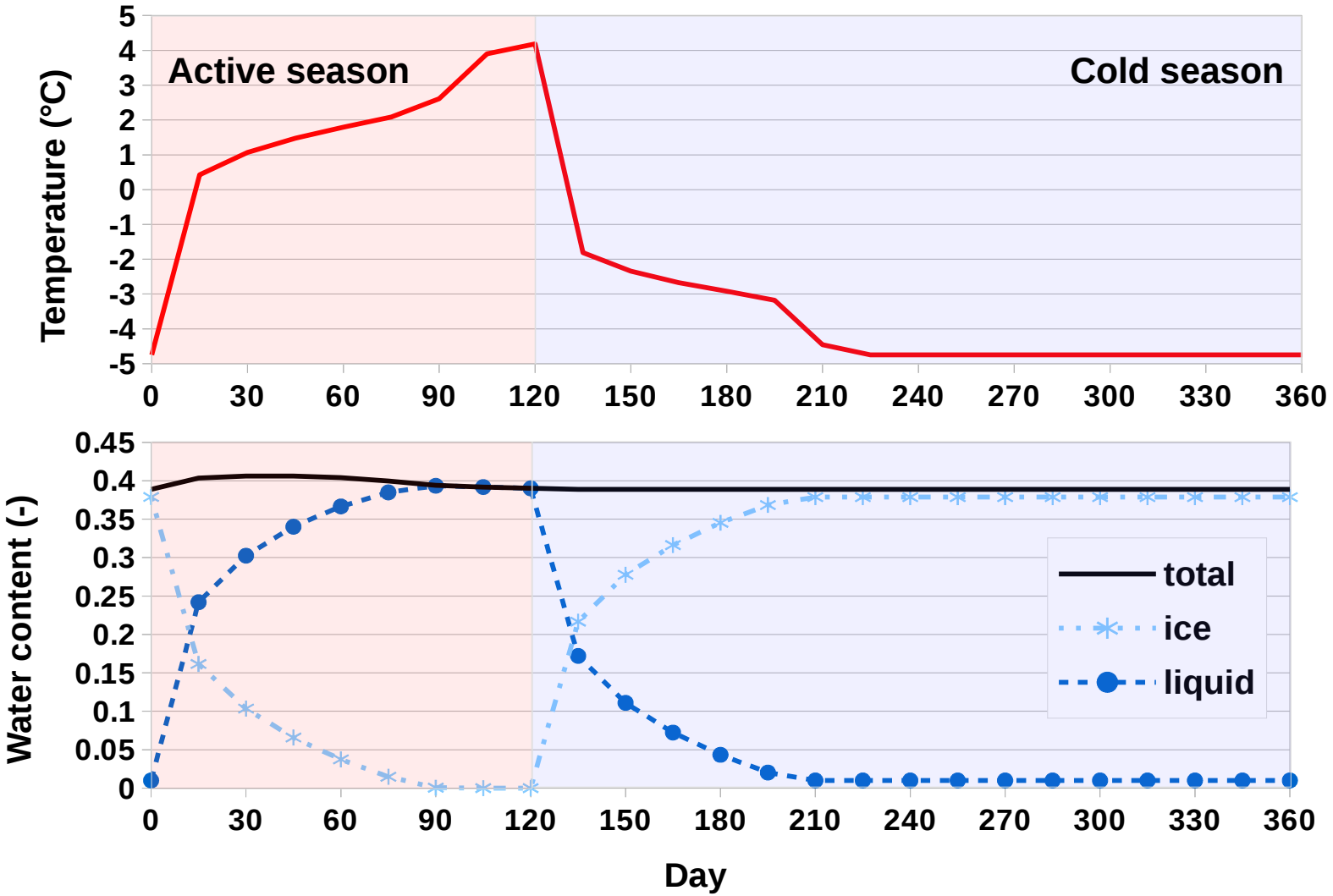


T (°C)

(paraFoam displays of the temperature field along computations; note that the use of the same T color scale for all figures hide partly the 2D patterns)

Example of results of the permaFoam_demoCase

Plotting the resPsi, resTheta, resThetal and resThetag postprocessing files:



Note that the values at the beginning of the year and at the end of the year are the same, according to the cyclic character of this test case.

Enjoy permaFoam !

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