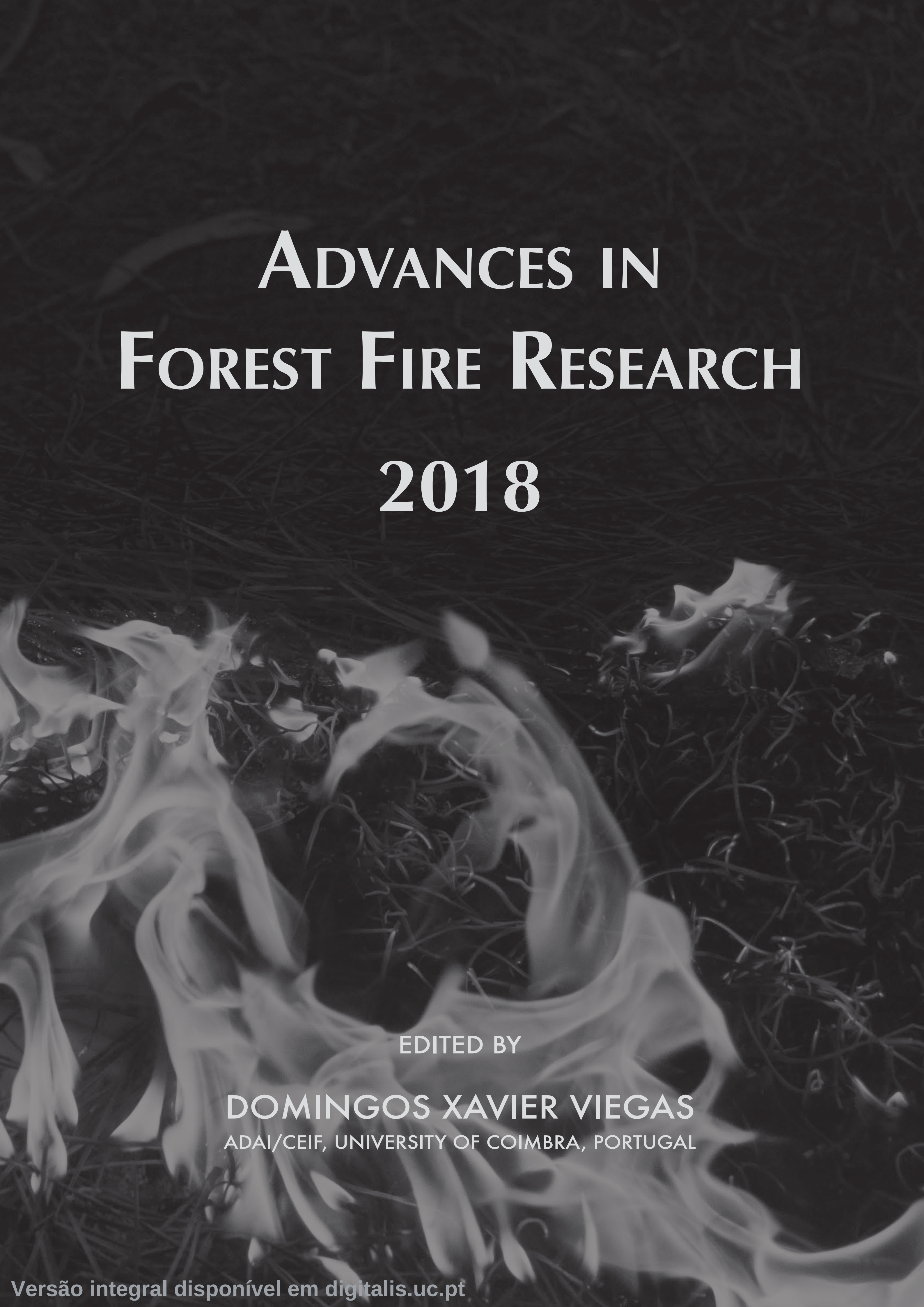

Advances in Forest Fire Research 2018

Edited by

Domingos Xavier Viegas
ADAI/CEIF, University of Coimbra, Portugal

https://doi.org/10.14195/978-989-26-16-506_99

An upper non-reflecting boundary condition for atmospheric compressible flow

Aurélien Costes* [1] ; Christine Lac[2] ; Valéry Masson[2] ; Mélanie Rochoux[3]
[1] *CERFACS, CNRM, Toulouse, France. {aurelien.costes@meteo.fr*}*
[2] *CNRM, Toulouse, France. {christine.lac@meteo.fr, valery.masson@meteo.fr}*
[3] *CERFACS, Toulouse, France. {melanie.rochoux@cerfacs.fr*

Abstract

So as to predict fire spread after its ignition, the Meso-NH atmospheric model has been coupled to the forest fire model ForeFire. Meso-NH uses the anelastic hypothesis that provides an intrinsic acoustic filter. Nevertheless, this approximation does not allow horizontal density variations which leads to problems close to the fire front because of the high heat release. That is why the full Euler compressible system shall be used to take into account air expansion at the fire level. This governing equations system transition comes with acoustic waves propagation. Although those waves are uninteresting for meteorology, they bounce on the ground and on the roof of the domain and disturb the inner solution. Indeed, the actual rigid lid as upper boundary condition does not allow acoustic waves radiation. The Rayleigh top damping layer already implemented in Meso-NH provides high frequency filtering, meaning that the new upper boundary shall only evacuate the remaining low frequency waves.

In order to build a reliable and precise upper boundary condition for a reasonable computational cost, we shall verify that the new boundary (1) lets low frequency waves pass through and (2) does not force the interior domain state. So as to preserve the scalability of the code, the boundary shall also (3) be localized in space and (4) as localized as possible in time to limit memory storage.

Several methods could be used to evacuate acoustic waves from the domain. Our requirements have conducted us to base our new upper boundary condition for Meso-NH on Characteristic-based Boundary Conditions, known as NSCBC, proposed by Poinsot and Lele. This boundary condition (BC) is known to be "non-reflecting" and also local in space and time. Nevertheless, the NSCBC formulation based on the characteristic theory of Thompson, comes out as "partially non-reflecting" as its behavior is more a low pass filter. An extended method called Plane Wave Masking, PWM, has been proposed by Polifke et al. to get a near zero reflexion coefficient for low frequency waves.

In PWM theory, the acoustic waves are assumed plane and incoming with normal incidence at the boundary. Nevertheless, the normal incidence of wave represents a strong limitation of the formulation. Lodato et al. have built a 3D formulation of NSCBC that computes transverse gradient to take into account oblique waves.

In purpose of testing the PWM formulation for its requirements, an offline model has been created in Python. This simplified model has been used to check the PWM boundary behavior facing plane waves and spherical waves. Once the PWM method has been proved as compliant to each requirement (1-4), it is implemented in the Meso-NH compressible code. Then, different academic and classic Meso-NH cases are run to ensure the correct behavior of the new boundary as orographic waves as well as fire experiments. The compressible assumption will be evaluated with the FireFlux experience.

Keywords: Acoustics, Boundary conditions, Non-reflecting, Meso-NH, Compressible, Computational Fluid Dynamics

1. Introduction

So as to predict fire spread after its ignition, the Meso-NH atmospheric model (Lafore et al. 1998, Lac *et al.* 2018) has been coupled to the forest fire model ForeFire (Filippi *et al.* 2009). Meso-NH uses the anelastic hypothesis that provides an intrinsic acoustic filter. Nevertheless, this approximation does