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Study of global change impacts on the inland navigation management: application on the Nord-Pas de Calais network

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Abstract

In a global change context, governments in Europe want to promote alternative transports as inland navigation or railway instead of road transport. As example, in north of France, a shift of 20% from road transport to these alternative transport solutions is expected by 2050. Reaching this goal requires not only the delivery of new infrastructures and equipment, but also the design of efficient management strategies. By focusing on waterborne transport, it is thus necessary to improve the management of the inland navigation networks particularly the water resource. Indeed, the waterborne transport accommodation is strongly linked to the available water resource. This will be a challenging point in a global change context.
The paper deals with the global change impacts on inland navigation networks. It aims at proposing new contributions as compared to past and current results of European projects on climate change and inland navigation. It appeared that the multi-scale modeling approach for inland navigation networks that was proposed during the last TRA Conference in Paris in 2014 is useful to determine the resilience of these networks and their ability to guarantee the navigation conditions during drought and flood periods. The proposed tools are developed to consider two space and time scales. The first approach is used to determine the water quantity that is necessary to accommodate the navigation during half a day, and the second allows the efficient control of the gates to keep the water level of each navigation reach close to its setpoint by rejecting disturbances and compensating the waves due to the lock operations. One example based on the real inland navigation network of the north of France is used to highlight the contributions of the multi-scale modeling approach.

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1. Introduction

The last report of the IPCC (*Intergovernmental Panel on Climate Change*) (IPCC, 2014) *confirms that human influence on the climate system is clear and growing*. Between 2000 and 2010, the increase of total annual anthropogenic GHG emissions came by 11% from transport. However, human have still the *means to limit climate change and its risks. In the transport sector, technical and behavioral mitigation measures could reduce final energy demand significantly below baseline levels*. Consistent with this report, a shift of 20% from road transport to alternative transport solutions is expected by 2050 in north of France[1]. Indeed, inland navigation transport provides economic and environmental benefits (Mihic, 2011; Mallidis, 2012), with safer transport of goods (Brand, 2012).

Inland navigation development requires the delivery of new infrastructures following the Trans-European network program (TEN-T[2]), but also the design of adaptive management strategies. Hence, it is necessary to better understand the dynamics of the inland navigation networks and what could be the impacts of climate change. The report of the PIANC (Permanent International Association of Navigation Congresses) lists the main impacts of climate change on navigation by considering also water quality (EnviCom, 2008). An exhaustive state of the art of European project reports and an analysis of the climate change effects on inland waterway transport are proposed in (ECCONET, 2012). Also in this report, policy guidelines have been developed to adapt the management of inland navigation channels. By focalizing on water quantity the GEPET-Eau project[3] aims at better understanding the impacts of climate change on inland navigation networks and at designing adaptive management strategies. To reach this objective multi scale modeling approaches and an adaptive and predictive control architecture have been proposed in (Duviella, 2014a). The first model consists in modeling the inland navigation network with a sample time of several hours. It is used to identify the main water intakes, the operating modes of the locks and gates, and finally the uncontrolled water supplies. Based on this model, a flow-based network is designed to represent the constraints on the flows and then to generate an optimization problem under constraints. Solving this problem allows determining volumes of water that are required for navigation on the horizon of several hours. These tools are used to design the *volume management* approach. Then according to these required water volumes, it is still necessary to control the gates with a sample time of several minutes to guarantee that setpoints are applied by rejecting disturbances. A first approach based on Model Predictive Control (MPC) with an Integral Delay Zero (IDZ) and Integral Resonance (IR) models have been designed respectively in (Horvàth, 2014a) and in (Horvàth, 2014b). More recently a MPC-IDZ is used to deal with several operating modes of a navigation reach in (Horvàth, 2015). These tools are used to design the *discharge management* approach.

The main objective of this paper is to present the several management tools that have been developed in the framework of the GEPET-Eau project and to show their complementarities to study the impacts of global change on inland navigation networks. The paper is structured as the following: section 2 is dedicated to the *volume management* approach. The *discharge management* approach is presented in section 3. In section 4, a part of the inland navigation network in north of France is presented to highlight the advantages of the proposed approaches. Finally, the summary and perspectives of this contribution are given in section 5.

2. *Volume management* approach

Inland navigation networks cover large territories in Europe. They are composed with interconnected rivers, channels and canalized rivers. They are equipped with controlled locks and gates, and with sensor networks (water flow meters, water level meters). The managers of inland navigation networks have to guarantee all the conditions for navigation, *i.e.* the navigation rectangle (*see* Fig. 1). Hence, the water levels have to be close to the Normal

[1] https://www.nordpasdecalais.fr/upload/docs/application/pdf/2014-09/schema_climat-web-170914.pdf
[2] http://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/index\en.html
[3] https://gepeteau.wordpress.com/enversion/