Study of two forested watersheds in Les Landes region: monitoring of carbon stock and water cycle over the last decades

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Introduction

Water availability influences strongly carbon stock as it is a determinant factor for forest distribution and a limiting factor for tree productivity.

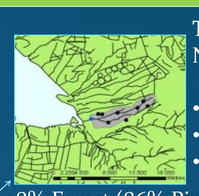
BUT

Few studies quantify feedback effects of the two cycles by a spatially explicit coupling between an hydrological and an ecological model.

Our project aims to implement a coupled eco-hydrological model to estimate effects of land cover and climatic changes, extreme climatic events, and forest management on water and carbon budgets for the last decades.

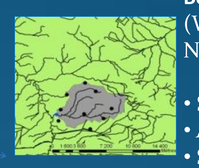
Experimental sites

Managed maritime Pine forests of Southwestern France covers nearly 1 million of hectares.



Tagon (W01°03'02", N49°63'18") :

- Surface : 22 km²
- Altitude : 60 m-1 m a.s.l
- Slope : 1% (max 4 %)
- 98% Forest (86% Pine), 2% Crops, 9% urban areas (*)



Bouron (W00°80'02", N49°42'31") :

- Surface : 48 km²
- Altitude : 80 m-16 m a.s.l
- Slope : 1% (max 16 %)
- 92% Forest (87% Pine), 6% Crops, 2% urban areas (*).

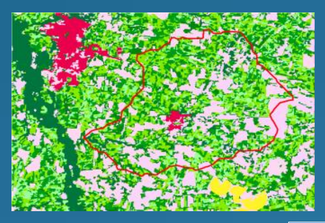
Land Cover map since 1983

1) Classification of 2007 multi-seasonal SPOT images : 14 classes of land cover type of witch 6 represent coarse age classes of maritime pine forest. Calibration and validation with ground survey (2000, 2008).

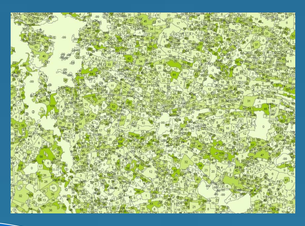
2) Refined using the date of clear-cut to know the age in 2007 (clear-cut map INRA 1984-1990 and IFN since 1990). The age of the oldest stands (before 1984) filled with statistic of the last ground-based forest inventory in the area.

3) Age "reconstitution" through time : remove one year to obtain the n-1 year map and when coming to the clear-cut year, statistical distribution of the age before cutting from IFN.

SPOT image



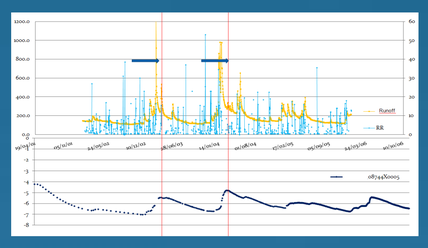
Segmentation



Age map in 1996

Climatic Data

From 1996 to 2008 : Météo France data, 8*8km, grid.
Since 2009 : weather stations on the watershed.



Rainfall, runoff and piezometric variation on the Bouron Watershed from may 2001 to october 2006 : correlation between a rain event and dynamic of the water.

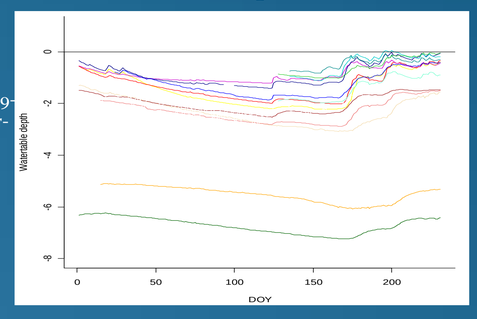
Hydrologic Data

Different type of wells: manual or automatic

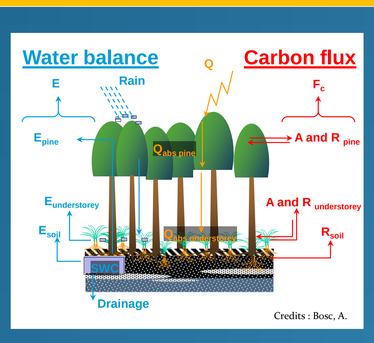
Groundwater table : 9 and 12 wells for the Bouron and Tagon watersheds, from 2 to 11 m deep; from 1976 at the earliest.

Runoff : 1 outlet for each watershed from 1967 at the earliest (Tagon's measurements were interrupted from 2006 until November 2009).

Progressive recharge of the water-table during winter 2009-2010. The deeper are the water-table, the smoother is the reaction to a rainfall event.



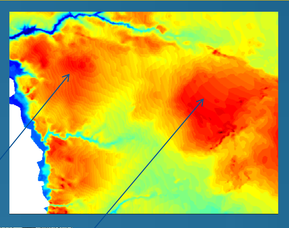
SVAT Model



Process-based model describing forest functioning : evapotranspiration, carbon balance, tree growth, management , energy balance, etc.)
=> calculate carbon budget and its evolution over time.

Modflow

Spatially-distributed ground water level will be simulated with MODFLOW (Chiang W-H., 2005).



First simulation with the model for the Bouron watershed show a great concordance with vegetation maps from dry to humid places.

Carbon stock and Water Budget evolution trough time

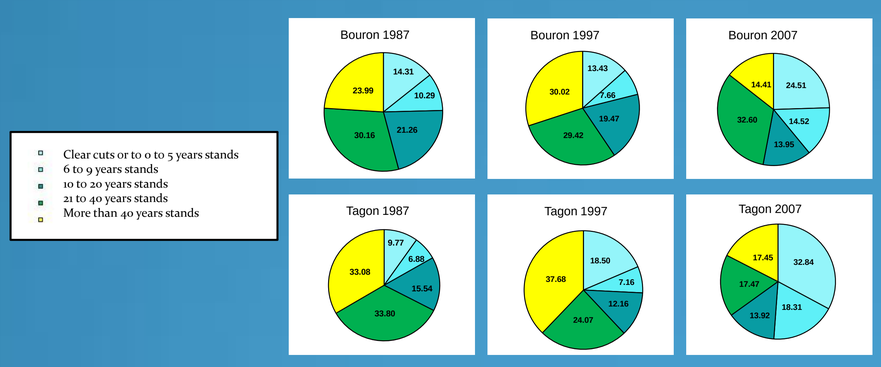
1999's Storm impact on stands

Tagon have been more damaged by the Martin (Dec. 1999) winter storm and Bouron by the Klaus (Jan. 2009) winter storm.

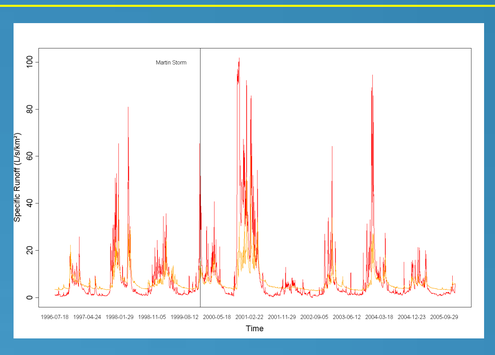
		Tagon	Bouron
Martin (1999)	P20	32.9	19.8
	P50	24.2	12.4
Klaus (2009)	P20	25.6	33.3
	P50	7.5	13.1

P20 : Percentage of the total surface of the watershed with damaged trees ratio higher than 20%.
P50 : Percentage of the total surface of the watershed with damaged trees ratio higher than 50%.

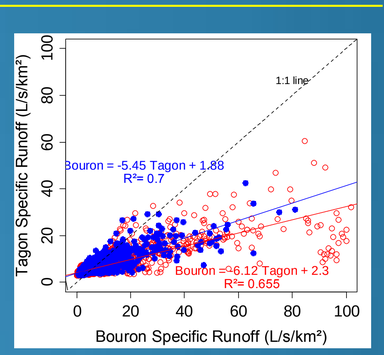
The 1999's storm had a deep and long term impact on the age distribution of the pine forest stands for the two watersheds.



1999's Storm impact on flows



Specific runoff from July 1996 to December 2005 : Red = Tagon, Orange = Bouron



Specific runoff before (blue) and after (red) the 'Martin' storm

Specific runoff of the Tagon watershed increases in comparison with the Bouron watershed after the 1999' storm, mainly due to an increase of flood flow during winter. These higher peak flows are still visible after four years.

This difference was highly significant with a t-value of 5.77 for 2522 ddl and p-value of 8.75e-09.

Perspectives

The next step of the study will be to implement the coupled eco-hydrological model to quantify the cumulative effects of land cover heterogeneity, temporal changes in land cover, progressive climatic shifts and abrupt events such as storm events and land use conversion, on watershed functioning over the two last decades.

Sources : (*) Corine Land Cover 2000, (**) IFN/CEMAGREF 1999 et 2009

Références : Chiang, W-H., 2005. 3D-groundwater modeling with PMWIN a simulation system for modeling. Springer-Verlag Berlin Heidelberg New York, 397 pages.