BUVARD online

BUVARD: an online tool to design vegetative buffer zones in a french context

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Irstea. Non point source pollutions team

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AGENCE FRANÇAISE POUR LA BIODIVERSITÉ

Établissement public du ministère de l'Environnement

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Background

Regulatory context

- Water Framework Directive ⇒ good ecological status for waterbodies
- Drinking water standards

Buffer Zones can be useful to prevent and limit the transfer of pollutants from agricultural fields to water resources, in parallel **with agricultural good practices**.

- Vegetated Filter Strips (VFS) are particularly useful for pollutants transported through surface runoff and sediment
- They need to be properly designed, considering the particular context in which they are implanted

Development of a specific tool to design VFS, once a diagnosis has been realized and VFS's position chosen:

BUVARD = BUffer strip runoff **A**ttenuation and pesticide **R**etention **D**esign tool

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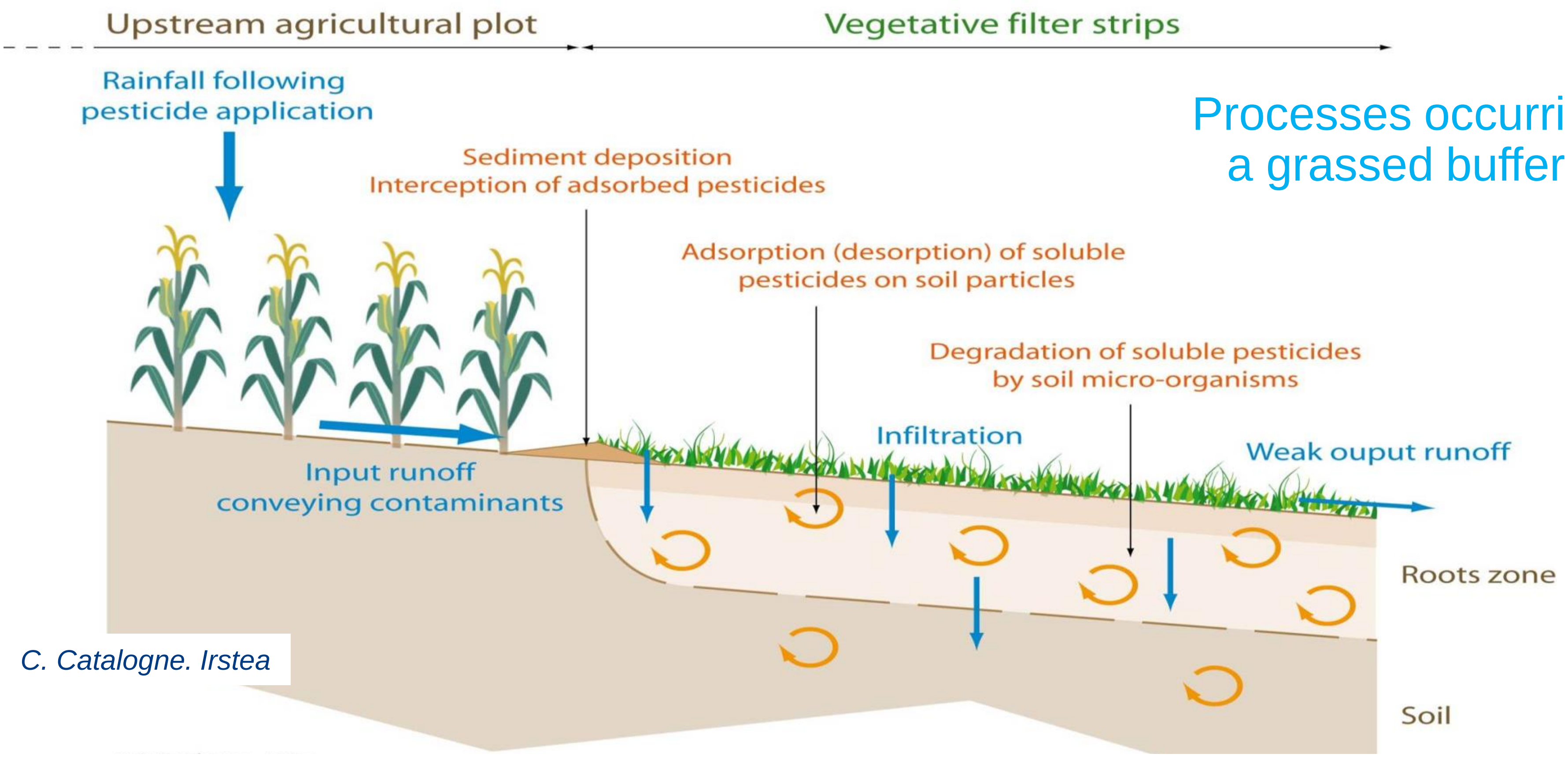
Key drivers of VFS efficiency



C. Catalogne. Irstea

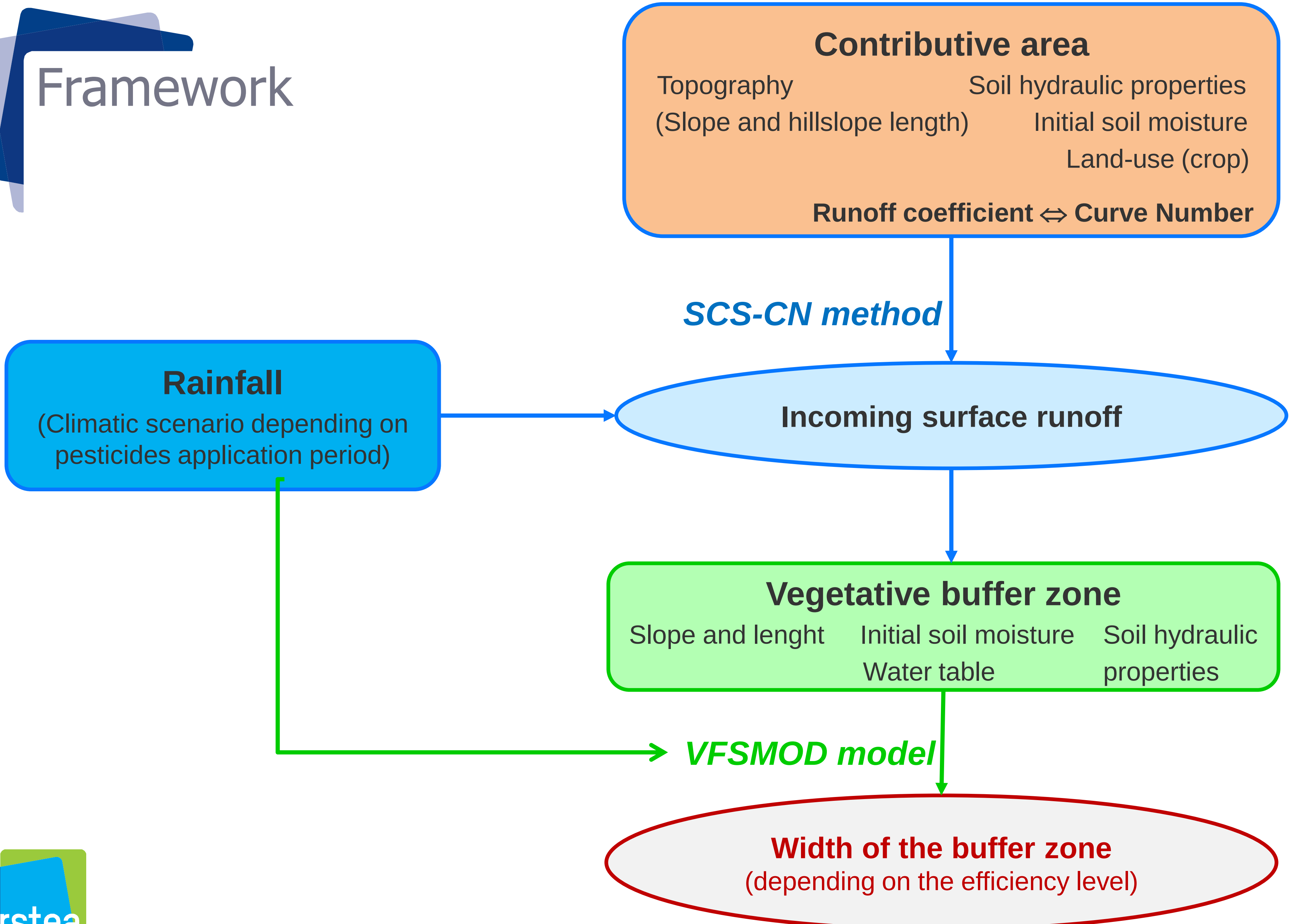
Processes occurring in a grassed buffer strip

The infiltration of water and pesticides is often the main process shaping pesticide transport reduction

- Diversity of the capacity of active substances to be sorbed (Koc) or degraded (DT50)
- Difficulty to assess the mobilization and transport of suspended matters

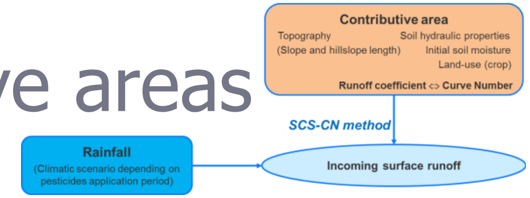
⇒ **BUVARD only considers surface runoff reduction**

Framework



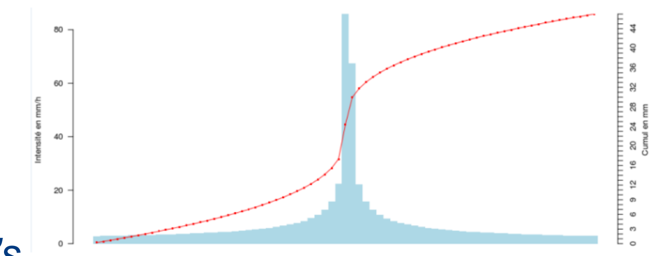
Carluer, N., C. Lauvernet, D. Noll and R. Munoz-Carpena (2016). "Defining context-specific scenarios to design vegetated buffer zones that limit pesticides transfer via surface runoff." Science of the Total Environment **575**: 701-712.

Surface runoff generated on contributive areas



Rainfall event characterization

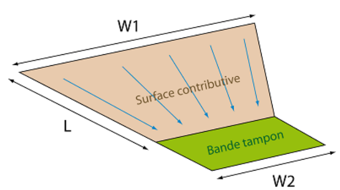
- Based on Intensity-Duration-Frequency rainfall French data.
  Return period of one year, per season; 4*4 km grid
  Several forms of hyetogramms are available
- *Parameters: geographical coordinates of the catchment's outlet, season, duration of the event, form of the rainfall event (moderate, intensive)*

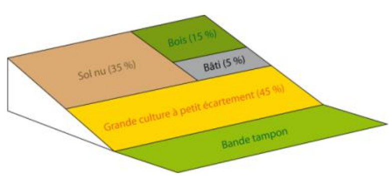


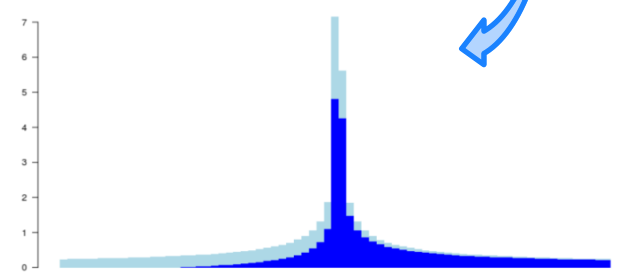
Hyetogramm

Incoming runoff event assessment

- Assessment of the net rainfall.
- Based on the Curve Number method (USDA-SCS, 1972)



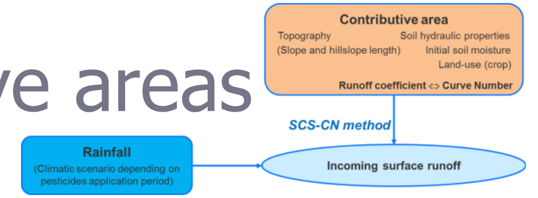




Net rainfall

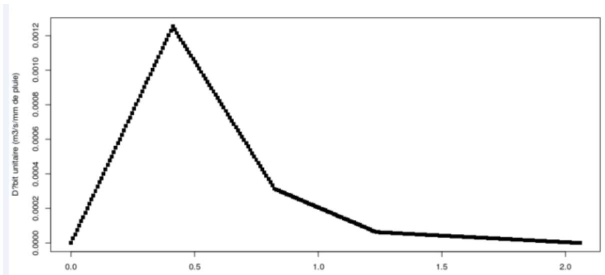
Parameters : Curve Number (kind of soil, soil occupation, hydrological conditions), initial humidity conditions

Surface runoff generated on contributive areas



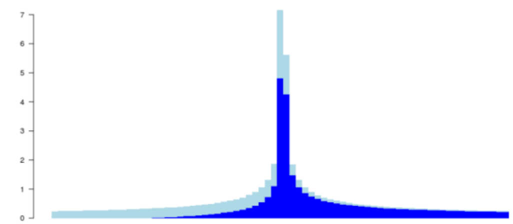
Incoming runoff event assessment

Parameters : lenght and surface of the contributive area

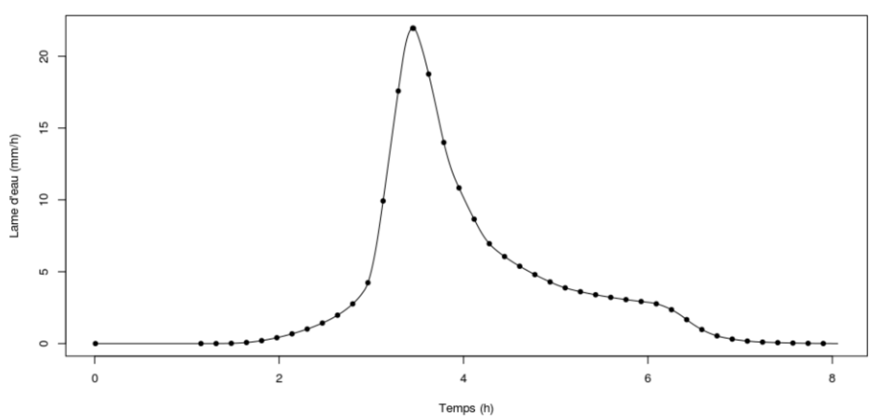


Unit Hydrograph

Convolution

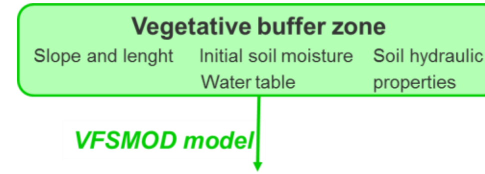


Net rainfall



Surface runoff discharge

Buffer zone efficiency modelling

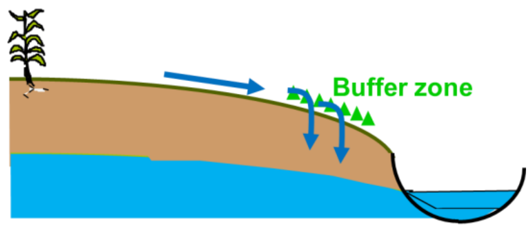


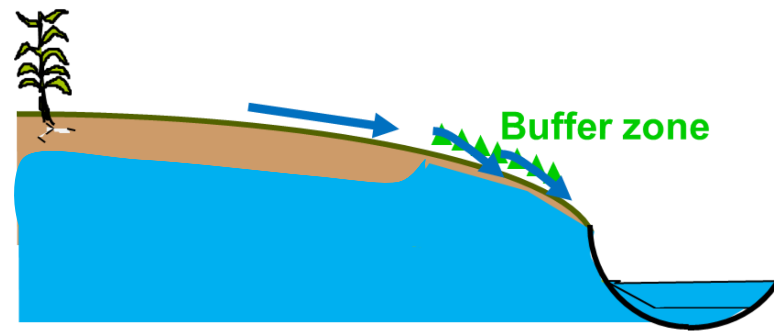
VFSMOD: a mechanistic model to represent water, sediment and pesticides transport inside a VFS.

Original version uses Green and Ampt equation to represent non limited infiltration

Yet, the presence of a water table may reduce infiltration capacities

(Gril, 2010)





⇒ Need to take into account the water table influence : VFSMOD is now coupled with SWINGO algorithm describing soil infiltration in presence of a water table

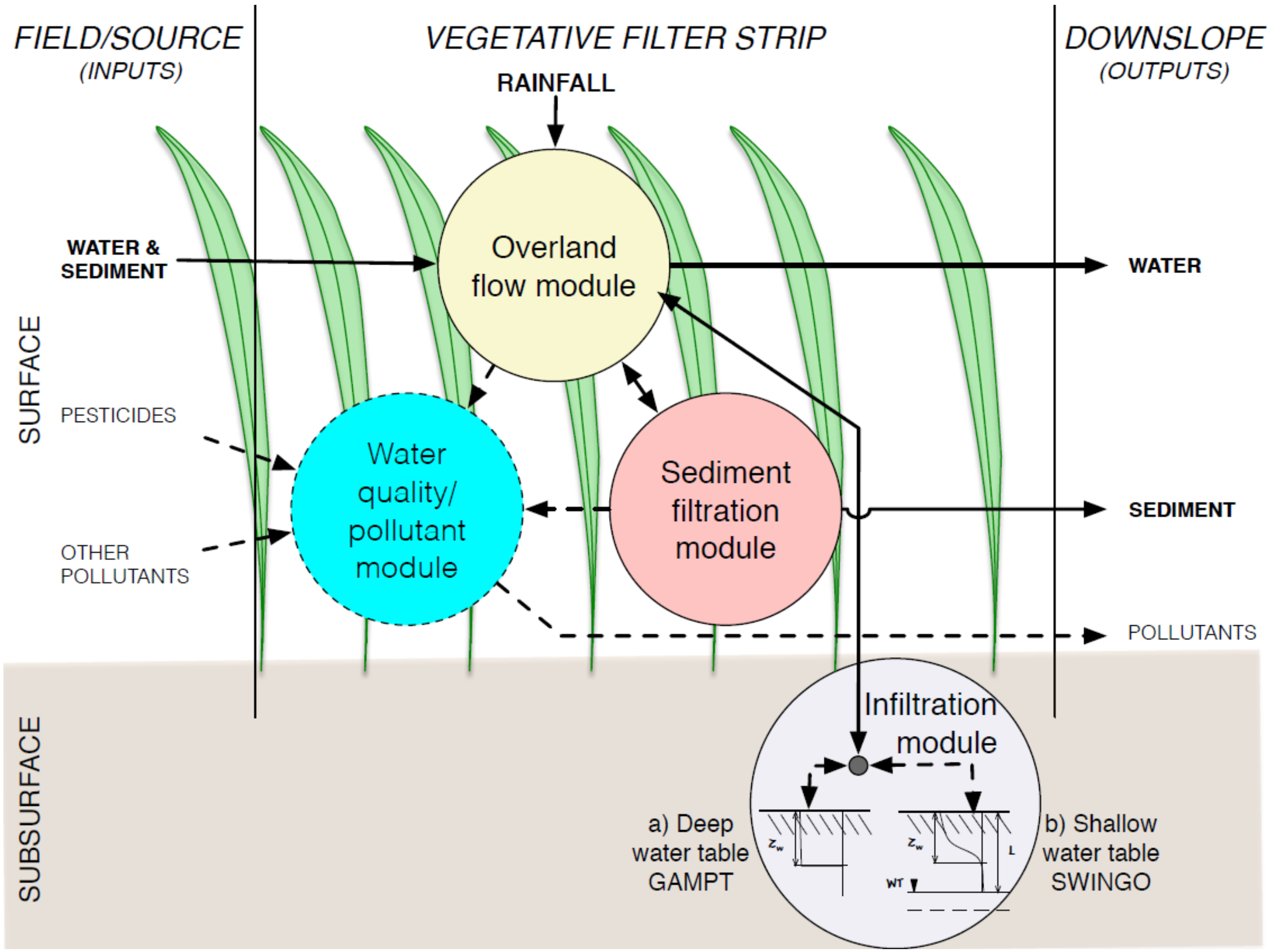
***R. Muñoz-Carpena, C. Lauvernet, N. Carluer*.** Shallow water table effects on water, sediment and pesticide transport in vegetative filter strips: Part A. Unsteady rainfall infiltration and soil water redistribution. *(Under review in HESS)*

***C. Lauvernet and R. Muñoz-Carpena*.** Part B. model coupling, application, factor importance and uncertainty. *(Under review in HESS)*

Buffer zone efficiency modelling

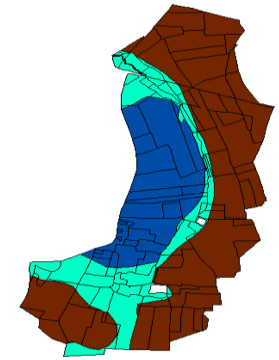
Vegetative buffer zone
Slope and lenght
Initial soil moisture
Water table
Soil hydraulic properties

VFSMOD model



*Parameters:Topography and dimensions (*slope, width), *Soil hydrodynamic characteristics (*Saturated Conductivity, Van Genuchten parameters*), Soil humidity status* (depth of the watertable)

Application of "comprehensive" BUVARD on a test catchment



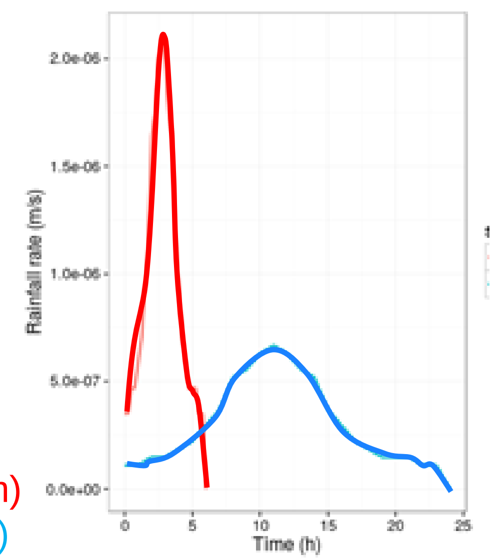
La Fontaine du Theil Catchment

- 128 ha, polyculture (maize, wheat, meadows) and breeding
- Brown soils (G1), brown leached soils (G2), hydromorphic brown soil in low lands (G3); frequent presence of a shallow water table
- Mean slope: 3.9%
- Monitored from 1998 to 2006 by ARVALIS and UIPP
- A diagnosis of the risk of pesticides transfers towards surface water was performed ⇒ proposal of VFS implantation (PROWADIS)

⇒ BUVARD was used to assess their optimal size.

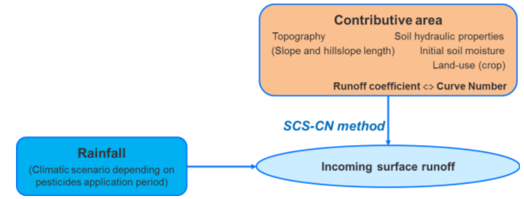
Designing representative scenarios:

- Two seasons: winter and summer
- Two rainfall scenarios per season:
  long and moderate / short and intense



Summer, long and moderate, 6 h (21.4 mm)
Winter, long and moderate, 24 h (26.7 mm)

Application of "comprehensive" BUVARD

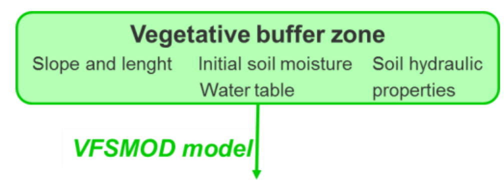


Designing representative scenarios, contributive area

- Two crops: wheat and cover crop / wheat and corn
- Two initial soil humidity status: moderate and wet
- Water table depths: 1, 2.5 and 5 m
- Crop % soil covering: 10 and 90 %
- Curve number values from 69 to 86 *(+8 points compared to USDA values)*

Scenarios: Sound combinations of the different modalities

Designing representative scenarios, VFS:



	G1	G2	G3
Reference layer	B	E	S
Ksat (mm/h)	13.17	6.97	10.59
n	1.95	1.92	1.98
alpha (m^{-1})	0.44	0.33	0.38
m	0.49	0.48	0.49
Saturated water content	43.5	39.9	42.7
Residual water content	11.700	10.400	10.900

VFS soil parameters, according to kind of soil

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Results, for a 70% efficiency level for surface runoff mitigation

Influence of hillslope length

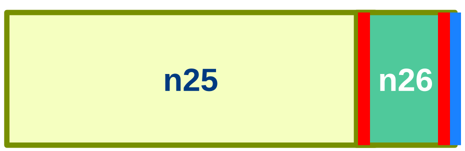
With no VFS between plots n27 and n28:

5 ; 12.4 ; 14.2

With a VFS between plots n27 and n28:

5 ; 8.4 ; 9.2

Influence of VFS soil

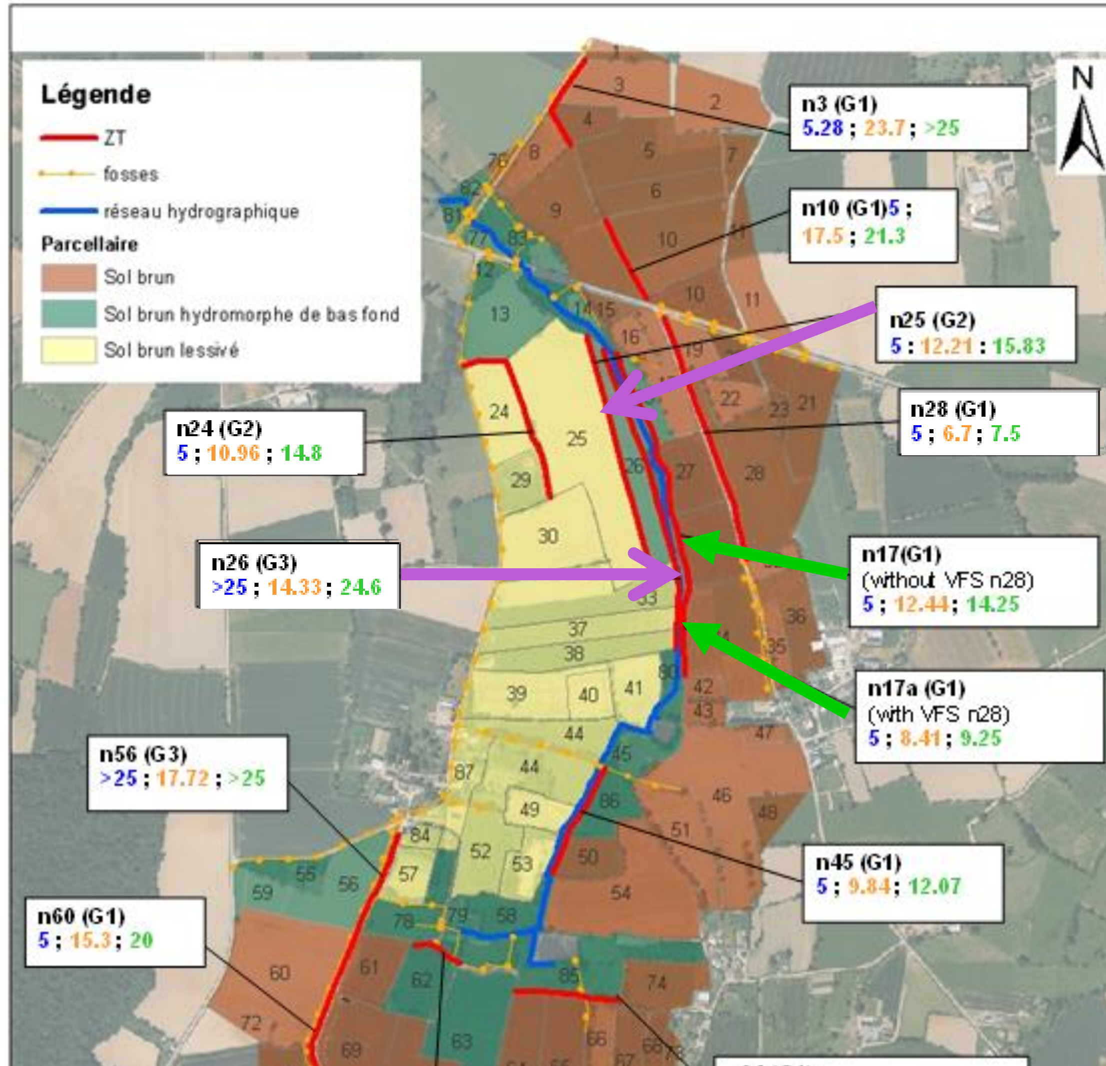


VFS in n25 (brown soil)

5 ; 12.2 ; 15.8

VFS in n26 (hydromorphic soil)

5 ; 14.3 ; 24.6



VFS dimensions for the different scenarios

- Winter scenario
- Summer conditions (2 hours rainfall)
- Summer conditions (6 hours rainfall)

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Learnings from "comprehensive" BUVARD application

- BUVARD allows to design each buffer zone by taking into account its characteristics as precisely as desirable
- Yet processing the entire method for each buffer zone is tedious

⇒ Evolution towards a more user-friendly approach

- Inspired from TOPPS-Prowadis project
- Based on the definition and pre-calculation of a large number of scenarios, covering a wide range of conditions

⇒ Elaboration of nomograms, accessible from a web-interface, along with an on-line help.

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Buvard online: choice of rainfall scenarios

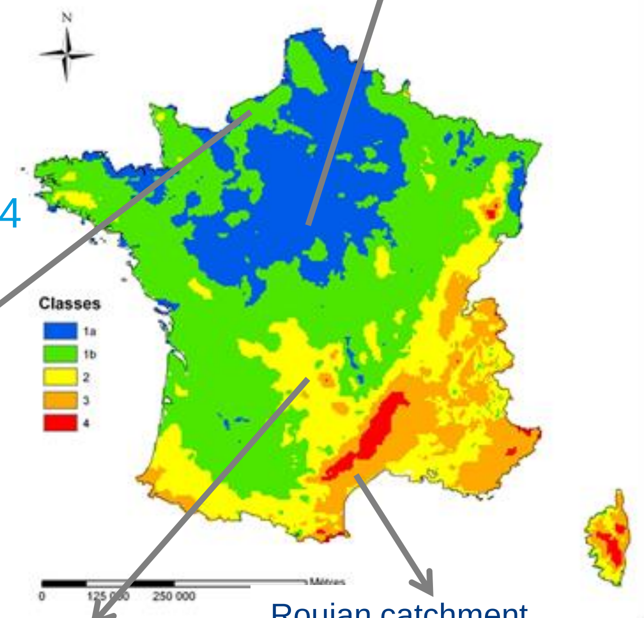
For each case, four rainfall scenarios are considered:

- Short summer rainfall (1 hour)
- Moderately long summer rainfall (6 hours)
- Short winter rainfall (2 hours)
- Moderately long winter rainfall (12 hours)

Based on available Intensity-Duration-Frequency French data, 4 climate areas were identified by automatic classification.

A reference hyetogramm is calculated and associated for each rainfall scenario

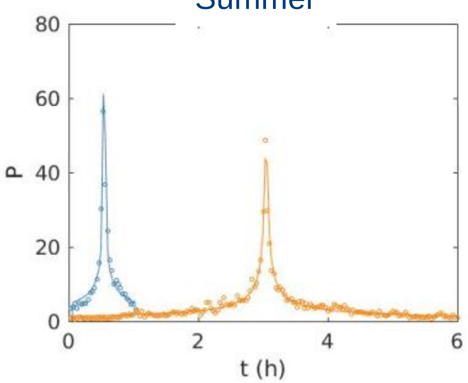
Orgeval catchment



Bourville catchment
1 and 6h summer rainfall

Yzeron catchment

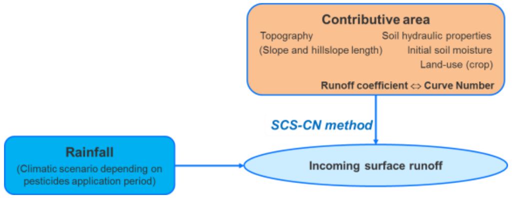
Roujan catchment



Buvard online: choice of scenarios

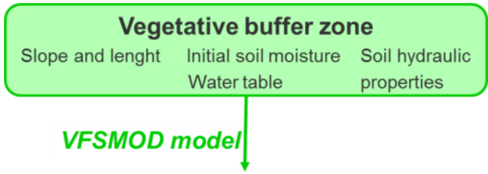
Incoming surface runoff

- 4 french climatic zones * 4 typical rainfall events
- Contributive area slope: 0.1;1 ;5 ;10 ;20 %
- Contributive area length: 25; 50; 100; 150; 200; 250; 300
- Curve Number: 42 to 99, step of 3
- Initial humidity status: 2, 3



Buffer zone

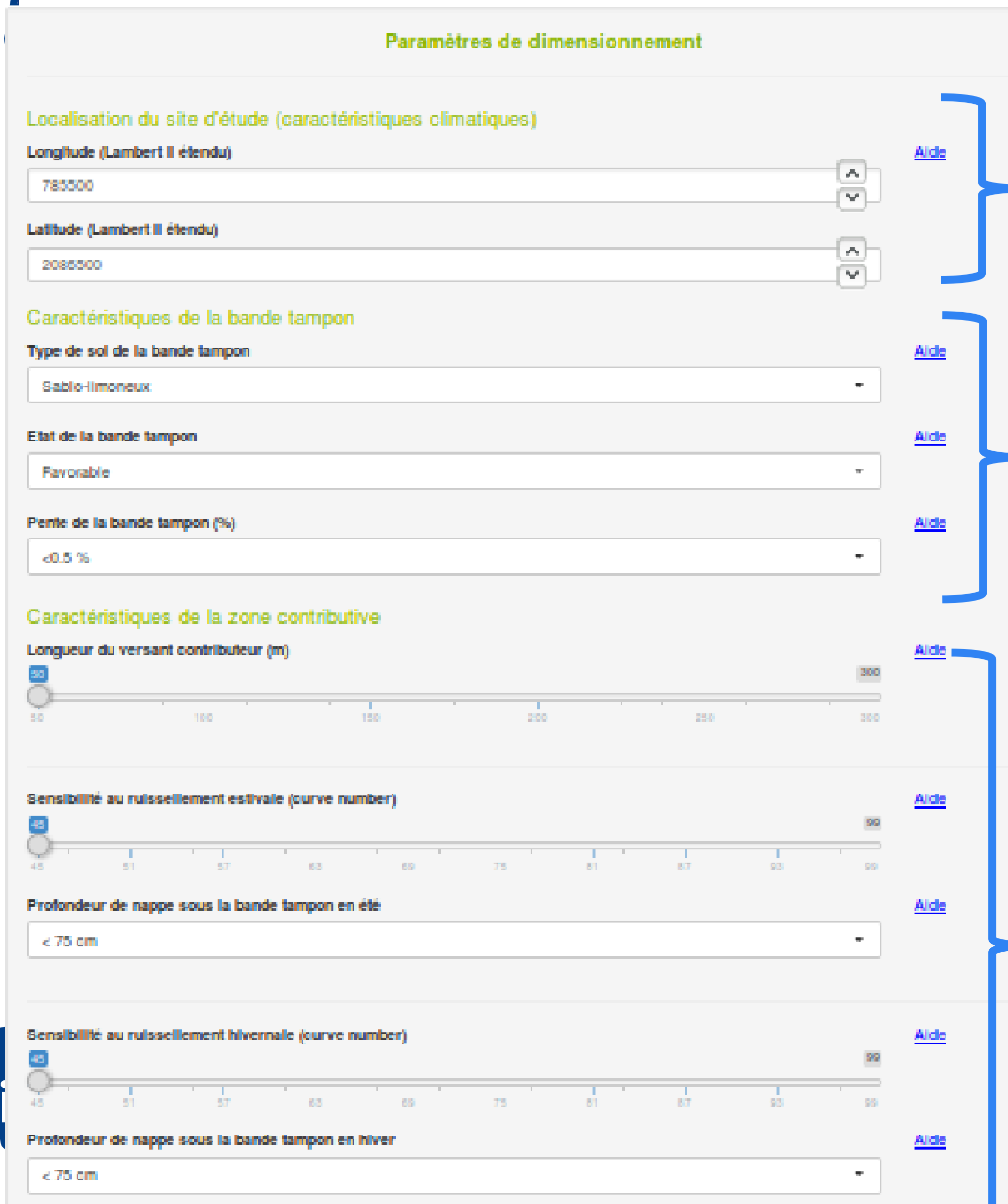
- 6 (4 + 2) kinds of soils, based on the AIM-TEC project
- Slopes: the same as the contributive area's one
- Width for optimisation: 1-3-5-7-9-11-13-15-20-25-30
- Water table depths: 050,100,200,400 cm



- 4*2*2 * 20*5*7 * 6*4 = **268 800 scenarios for VFS**
- 11 widths of VFS * 268 800 => **2 956 800 simulations**

Brown, C., Balderacchi, M., van Beinum, W., Capri, E., Trevisan, M., 2012. Definition of Vegetative Filter Strip Scenarios for Europe. Environment Department, University of York, Heslington, York, YO10 5DD, UK, p. 71.

Buvard online: https://buvard.irstea.fr



Catchment geographic position (climatic zone)

VFS characteristics

Characteristics of the contributive area

Buvard online

Example of online help for the choice of the VFS soil

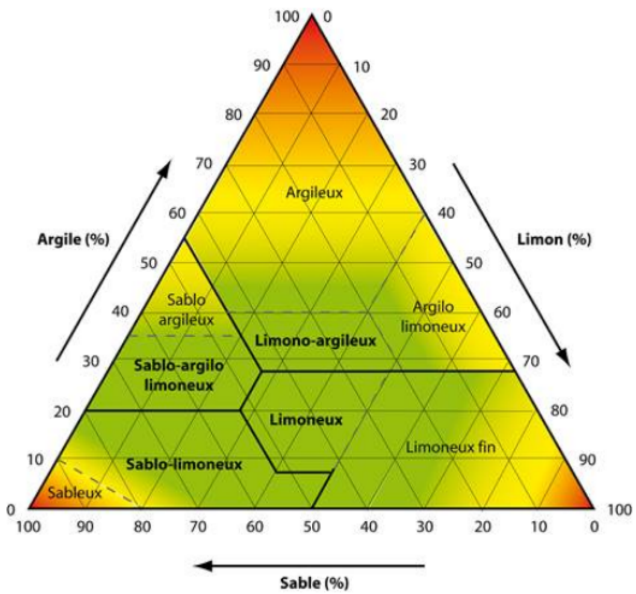
Détermination du type de sol de la bande tampon

Le choix du type de sol de la bande tampon se rapporte simplement à sa texture, c'est-à-dire sa teneur relative en argile, limons et sables (cf. diagramme triangulaire ci-dessous). Avec une certaine habitude, celle-ci peut-être estimée sur le terrain à l'aide d'un prélèvement effectué à la tarière. Une analyse granulométrique (par tamisage par exemple) est toutefois recommandée pour obtenir un résultat fiable (voir les méthodes de détermination de la texture recommandées par l'Organisation des Nations unies pour l'alimentation et l'agriculture : ftp://ftp.fao.org/fi/cdrom/fao_training/FAO_Training/General/x6706f/x6706f06.htm). Si possible, les variations de texture avec la profondeur seront prises en compte, **en retenant la texture la plus défavorable en termes de capacité d'infiltration dans les 50 premiers centimètres de profondeur**.

Le recours à des bases de données pédologiques est aussi une solution intéressante (BDGSF : https://www.gissol.fr/tag/bdgsf, BDAT : https://www.gissol.fr/le-gis/programmes/base-de-donnees-danalyses-des-terres-bdat-62). La texture (ou la classe texturale) s'avère en effet souvent l'un des premiers paramètres renseignés dans ces bases de données. Il faut cependant rester prudent en raison de la résolution de ce type de données, souvent insuffisamment détaillée pour restituer toute la variabilité spatiale des sols, notamment aux échelles considérées pour l'implantation d'une bande tampon.

L'utilisation du triangle des textures ci-dessous est proposée pour déterminer la catégorie texturale de sol à partie des données de texture. Sont reportées :

- En vert : les quatre textures proposées dans l'interface.
- En jaune : les textures proches pouvant leur être assimilées si elles sont rencontrées sur le terrain, en considérant les résultats avec prudence.
- En rouge : les textures pour lesquelles les résultats fournis dans l'interface ne peuvent plus être considérés comme valables.



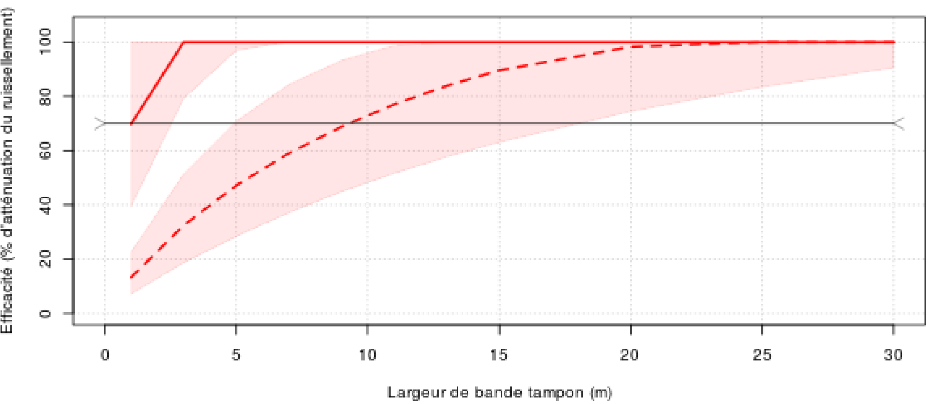
Buvard online

Results

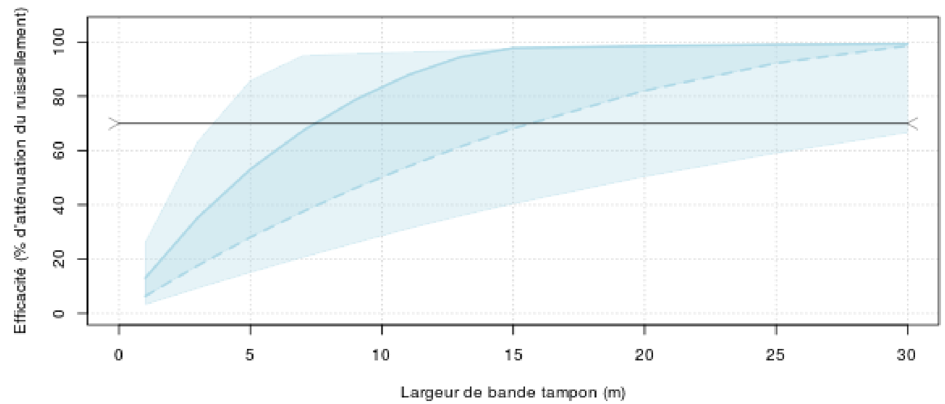
Average initial conditions

Wet initial conditions

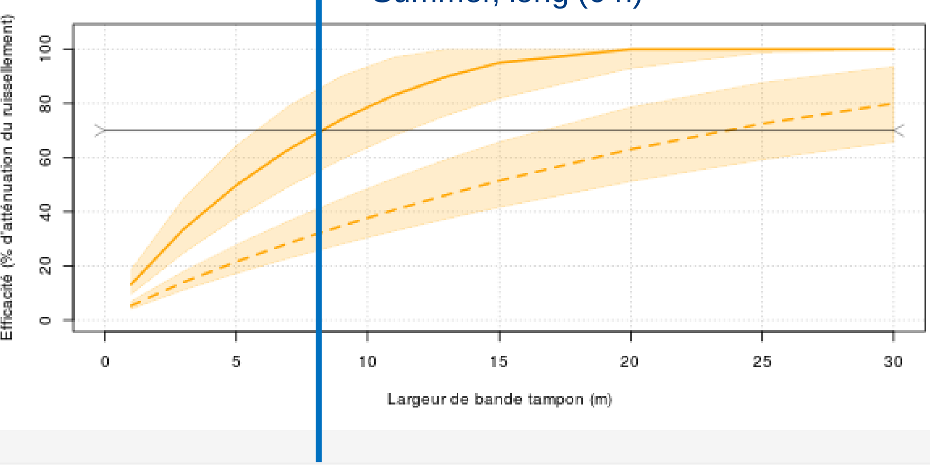
Summer, short (1 h)



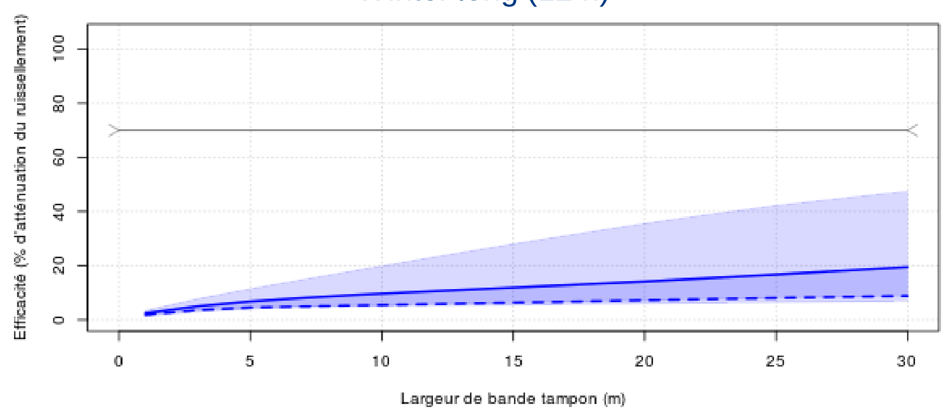
Winter short (2 h)



Summer, long (6 h)



Winter long (12 h)



Comment lire mes résultats ?

Conclusions. Perspectives

BUVARD allows to design VFS by taking into account the very local characteristics of their position, given a desired efficiency level

- « Comprehensive » BUVARD can describe all situations. *For experienced users*
- BUVARD-online is simpler to use, yet restricted to a given (very large) number of cases. *For non-experienced users*
- BUVARD-MM (MetaModel) will allow to continuously cover the whole range of simulated scenarios. *(Extension of BUVARD-online)*

VFSMOD makes it possible to simulate suspended matters and pesticides, given data is available

Application to European sites:

- Readily possible for « Comprehensive » BUVARD, if local rainfall data is available
- Would be possible for BUVARD online (and BUVARD-MM) if regional rainfall scenarios are available

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For BUVARD use, please visit the model's main web site from October 2017:

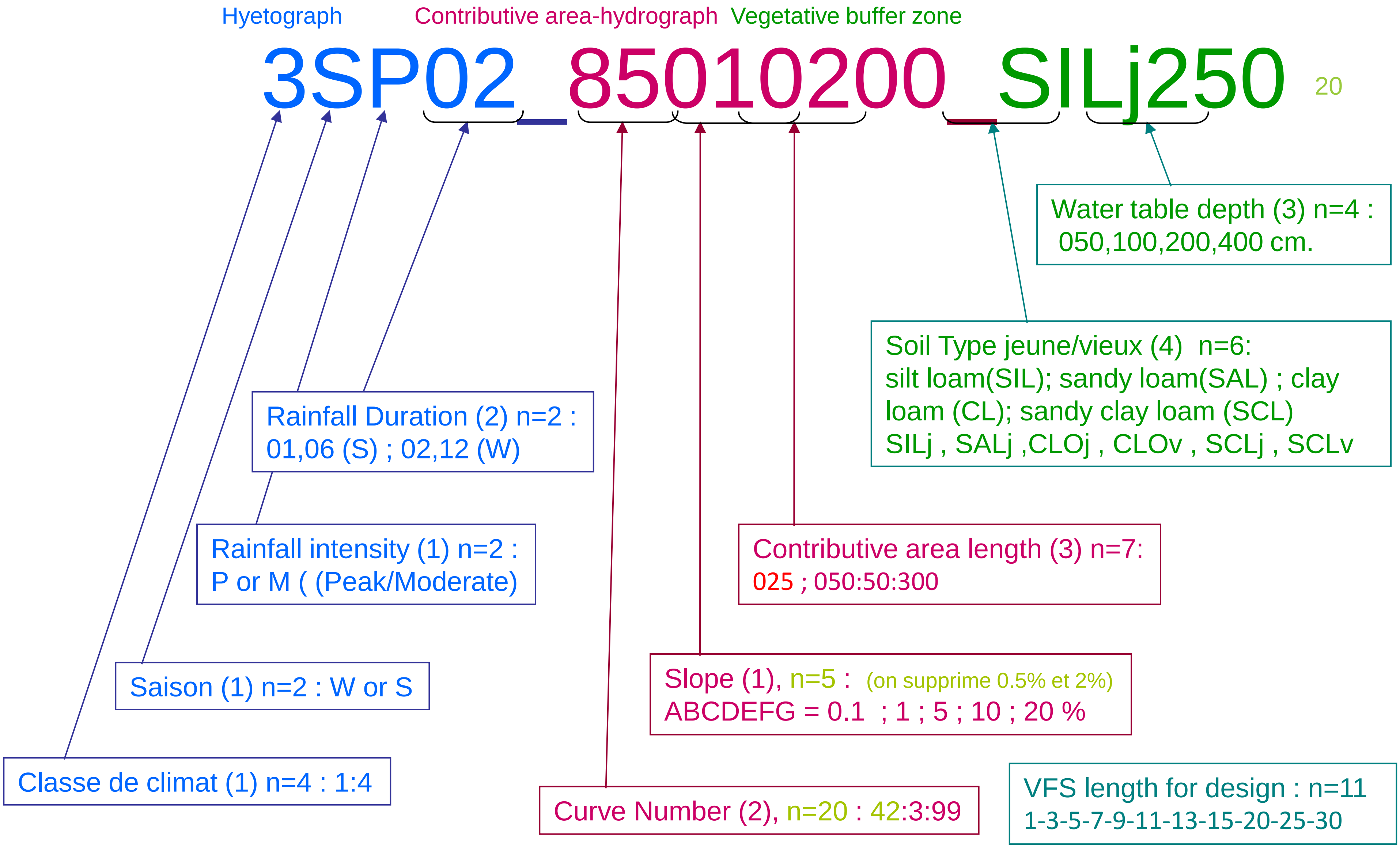
https://buvard.irstea.fr

or suscribe to the diffusion list to be notified when it becomes useable

zt_eq_PollDiff@irstea.fr

Thank you for your attention

nadia.carluer@irstea.fr



Entre () le nombre de caracteres => toujours 20 caract.
n= le nombre d'éléments
Nb scénarios = 4*2*2 * 20*5*7 * 6*4 = *(244608)* 268 800 scénarios
Nb simus = 11 lgr VFS * 268 800 = (*2 690 688)* => 2 956 800

Buvard online: https://buvard.irstea.fr

BUVARD online

Bienvenue dans la fenêtre de dimensionnement de votre bande tampon

1) Renseignez un-à-un tous les paramètres décrivant votre site d'étude dans le panneau de gauche en vous aidant de l'aide
2) Examinez les résultats pour les différents scénarios implémentés en fonction de l'efficacité recherchée
3) Déterminez la largeur de bande tampon optimale et exportez vos résultats.

Choice of the scenario

Localisation du site d'étude (caractéristiques climatiques)

Longitude (Lambert II étendu) Aide

785500

Latitude (Lambert II étendu)

2086500

Caractéristiques de la bande tampon

Type de sol de la bande tampon Aide

Sablo-argilo-limoneux

Etat de la bande tampon Aide

Favorable

Pente de la bande tampon (%) Aide

2 à 7.5 %

Caractéristiques de la zone contributive

Longueur du versant contributeur (m) Aide

50 — 200 — 300

50 100 150 200 250 300

Sensibilité au ruissellement estivale (curve number) Aide

45 — 81 — 99

45 51 57 63 69 75 81 87 93 99

Profondeur de nappe sous la bande tampon en été Aide

150 - 300 cm

Sensibilité au ruissellement hivernale (curve number) Aide

45 — 93 — 99

45 51 57 63 69 75 81 87 93 99

Profondeur de nappe sous la bande tampon en hiver Aide

75 - 150 cm

	Winter						Summer					
	G1		G2		G3		G1		G2		G3	
Crop	Wheat	Interme-diate crop	Wheat	Interme-diate crop	Wheat	Interme-diate crop	Wheat	Corn	Wheat	Corn	Wheat	Corn
Ksat (mm/h)	14,53		14,53		11,08		14,53		14,53		11,08	
Texture	silt-loam		silt-loam		silt-loam		silt-loam		silt-loam		silt-loam	
Initial hydrological group	C		C		C		C		C		C	
Water table depth	5		5		1		5		5		2.5	
Final hydrological group	B		B		C		B		B		C	
Hydrological conditions	unf	fav	unf	fav	unf	fav	fav	unf	fav	unf	fav	unf
Crop % soil covering	10	90	10	90	10	90	90	25	90	25	90	25
Curve Number II	84	69	84	69	92	82	83	89	83	89	83	89
Curve number III	92	84	92	84	96	91	92	95	92	95	92	95

VFS Soil parameters

Soil	Silt loam	Sandy loam	Clay loam	Sandy clay loam
Nomenclature	**SIL**	**SAL**	**CLO**	**SCL**
AIM-Tec project soil	R1	R2	R3	R4
n (Van Genuchten)	1.6647	1.44	1.45	1.3636
Alpha (1/m)	0.54	2.4	1.01	1.91
Theta_r	0.0679	0.055	0.0833	0.0655
Theta_sat VFS	0.458	0.478	0.456	0.49487
Theta_sat Rosetta	*0.4538*	*0.4674*	*0.4282*	*0.3984*
Ksat VFS (cm/day)	23	98.626	49.487	53.934
Ksat Rosetta (cm/day)	*30*	*109.3*	*6.72*	*12.89*
Ksat SWC (cm/day)	*14*	*102*	*7.1*	*18*