Revue d'ensemble des modèles de prévision d'inondation
Focus sur les méthodes par automates cellulaires

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Vue d'ensemble des méthodes, modèles et logiciels

Empiriques/Historiques

Basée sur des mesures de terrains et sur l'analyse statistique des historiques d'évènement de passés. [1]

Topographiques

Méthodes basées sur l'analyse du MNT pour décrire la propagation et l'accumulation du ruissellement

EXZECO [17], HAND [18], GeoFlood [19], MHYST [20] , GUFIM [21], MIKE-FLOOD [22], CHYM [23], ISIS FAST [24], RUFIDAM [25], SPM [26], HIM [27], Caffé [28], Autres [29,30]

Conceptuelles simplifiées

Méthodes caractérisées par une faible dimensionalité et une forte simplification de la modélisation physique.

- Les approches globales : territoire vu comme homogène
  SCS [2], USLE [3], CREAMS [4], RUSLE [5], SWMM (USEPA) [6]
- Les approches par indicateurs
  GFI [7], IRIP [8], SCALES, ERRUISSOL
- Les approches par réseaux de dépressions (Storage-cells) :

Découpage de l'espace en zones d'accumulation élémentaires communicant entre elles par un réseau de canaux : *ANSWER [9], EUROSEM [10], HEC-1 [11], KINEROS [12], WATERSED, Flood Modeller Fast Solver [13], RFSM [14], RFIM [15,16]*

Hydrodynamiques

Méthodes / logiciels basés sur la résolution des équations de Saint Venant dans leur version complète 2D ou suivant diverses approximations (modèles d'ondes diffusives qui néglige l'inertie, et d'onde cinématique qui néglige les termes d'inertie et de pression) ou 1D adapté à la simulation de cours d'eau (écoulement moyenné dans la direction transverse)

- Saint Venant : *ANUGA [31], B-Flood [32], Basilisk 2D [33], Brezo [34], Cartino 2D [35], DIVAST [36], DHD Iber [37], Flo2D [38], Floodos [39], Flood Modeller Pro 2D [40], HYDRO_AS 2D [41], InfoWorks [42], Isis 2D [40], MIKE 21 [43], MODFLOW [44], PRIMo [45], SOBEK [46], SRM [47], TELEMAC2D [48], TRENT [49], TUFLOW [50]*
- Onde cinématique : *HEC-HMS* - Onde diffusive : *CaMA Flood [51], JFLOW [52], UIM [53],* - Diffusive+inertie : *LISFLOOD-FP [54]*
- Saint Venant 1D : *Cartino 1D [55], ESTRY [56] Flutor, HEC-RAS [57], ISIS 1D [58], MASCARET [59], MIKE 11 [60]*

Approche	Forces	Faiblesses
Empirique	Intrinsèquement adaptée au territoire considéré	Données limitées, Taille des échantillons
Conceptuelle	Très Rapide, Simulation à échelles nationales et continentales	Emprise et hauteurs uniquement Régime permanent seulement Prise en compte limitée d'autres facteurs
Topographique	Rapide, Simulation à échelles régionales et nationales Prise en compte fine de la topographie	Régime permanent seulement Emprise et hauteurs uniquement Pas de prise en compte d'autres facteurs
Hydrodynamique	Précision des résultats Dynamique des écoulements Modélisation physique ajustable à la complexité recherchée	Calculs lourds Compromis performance / complexité Simulations à échelle locale

Vue d'ensemble des méthodes par automates cellulaires

Une approche par CA mobilise 4 éléments [61] : Un maillage + Un voisinage + Des états de cellules + Des règles de transition

Les approches par CA ont été appliquées à une grande variété de situations :

Urb.	Inondation en milieu urbain
Fast	Inondation éclair (Flash floods)

Riv.	Rivière / Crues
BV	En plaine / échelle du bassin versant
Rés.	Réseau d'assainissement

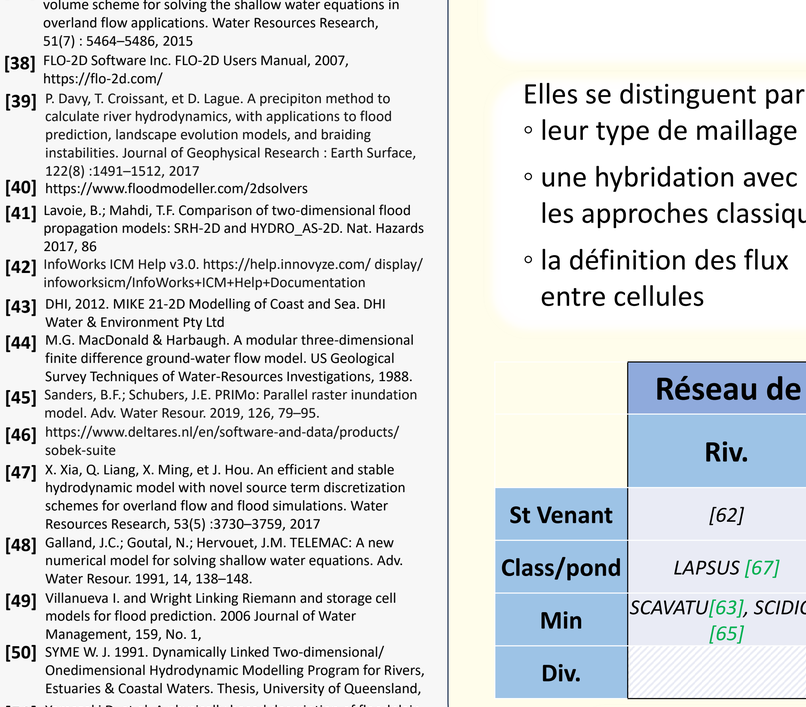
Elles se distinguent par
- leur type de maillage
- une hybridation avec les approches classiques
- la définition des flux entre cellules

Rast.	Basé sur des rasters
[XX]	Conceptuelle
[XX]	Topographique
[XX]	Multi-Physique
St Ven.	Saint Venant + approximations
Cla /Pon	Système de classement/pondération
Dép./NS	Réseau de dépression/ Maillage non structuré
Min.	Minimisation d'une fonction de coût
Div.	Divers / Autres

	Réseau de dépressions /Maille non structurée					Basé sur des rasters					
	Riv.	**BV**	**BV Fast**	**Urb. Fast**	**Rés.**	**Riv.**	**BV**	**BV Urb. Fast**	**Fast**	**Urb.**	**Urb. Fast.**
St Venant	*[62]*	*SWWM-2CA [79]*				*CAESAR [66]*	*[69], [71], MCA [75], [93]*			*HIM [87]*	
Class/pond	*LAPSUS [67]*							*WCA2D [72,77,88]*	*AQUA [70]*		*Caffé [86]*
Min	*SCAVATU[63], SCIDICA [65]*						*RunCA [76]*			*[89], [90], CAMC [91]*	*[84]*
Div.		*RuiCells [68]*	*RuiCells [74,85]*	*RFSM [83]*	*CACHYM [80], [81], [82]*	*CRS [64]*	*[73], 2CAFDYM [78]*			*RRCA [92]*	

Les approches raster + St-Venant sans inertie sont mathématiquement équivalentes à des solveurs explicites par volumes finis suivant l'approximation à inertie nulle. [94]

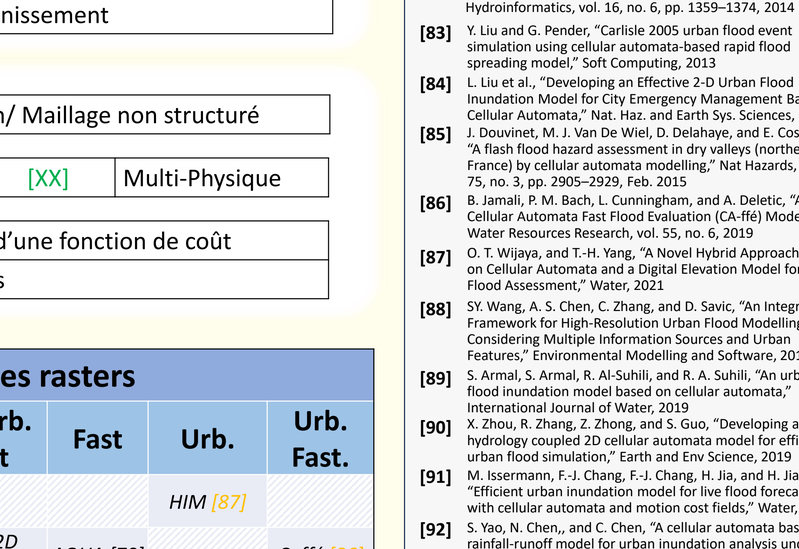
MICA : une solution ultra-rapide de simulation par automates cellulaires sur le cloud



Bluemapping propose une solution de modélisation du ruissellement et des inondations pluviales par automate cellulaire (algorithme inspiré de [72,77]) **parallélisé sur GPU** et adapté au calcul haute performance **(HPC) sur le cloud**

Algorithme ultra-rapide par automates cellulaires

1. Infiltration selon les lois de Green Ampt [95] - Van Genuchten [96]
2. Calcul parallèle des volumes d'eau transférés
3. Limitations physiques du taux de transfert local
   - Loi de Manning
   - Continuité du transfert entre deux itérations
   - Vitesse critique



3 min 50s pour simuler sur un maillage de **1600x1700** cellules un évènement de **12 h** (**125 500 itérations)**

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