

Using SURFEX for Mediterranean flash-flood forecasting within HYMEX program

B. Vincendon, V. Ducrocq,
S. Edouard, A. Lovat

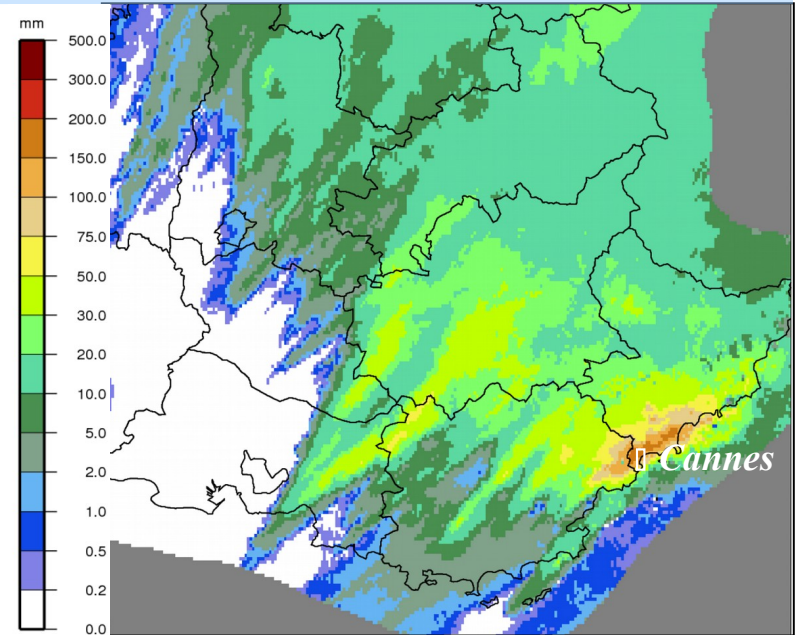
*GAME/CNRM (Météo-France, CNRS)
Toulouse, France*

Mediterranean Flash-Floods



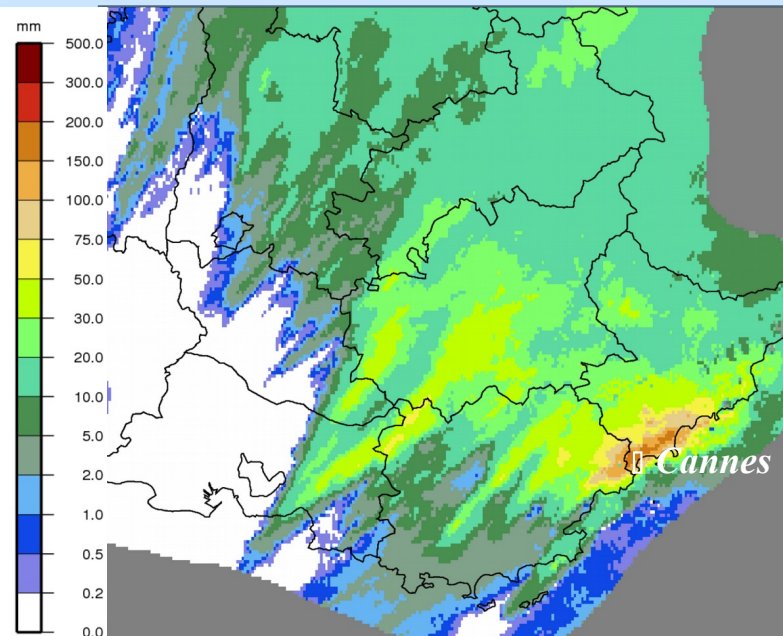
Mediterranean Flash-Floods

3h-accumulated rainfall (mm): 03/10/2015(17-20 UTC)

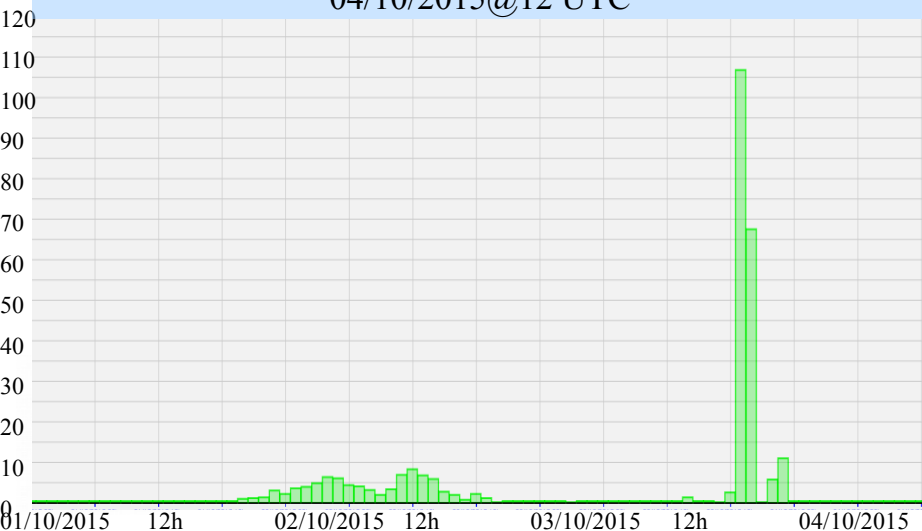


Mediterranean Flash-Floods

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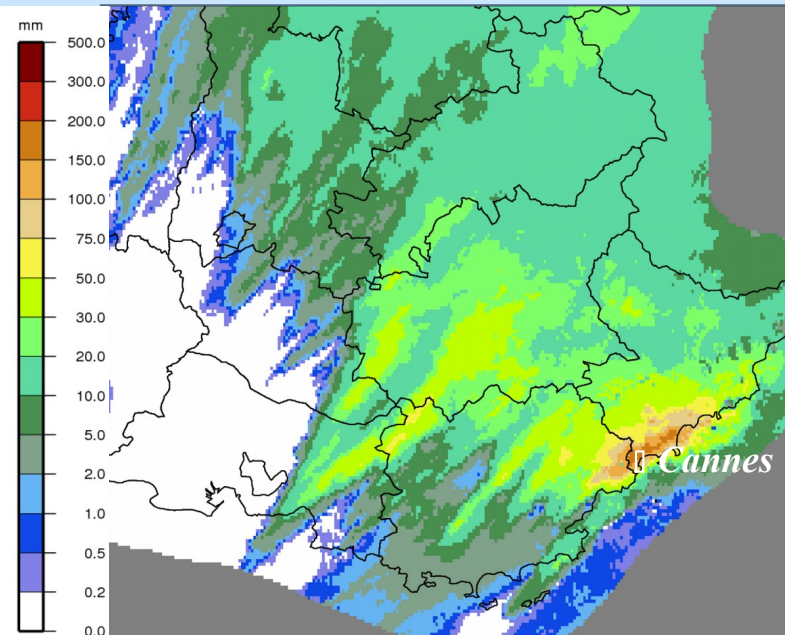


Hourly rainfall in Cannes (mm) from 01/10/2015@00UTC to 04/10/2015@12 UTC

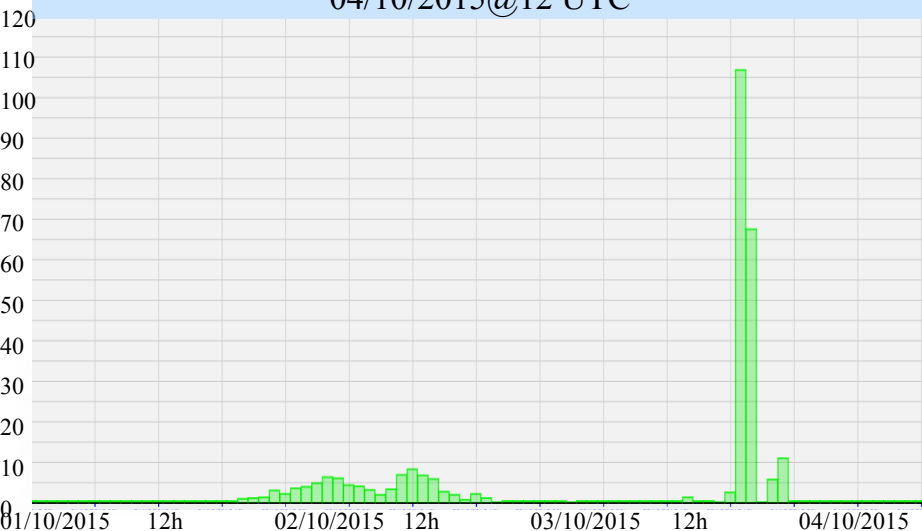


Mediterranean Flash-Floods

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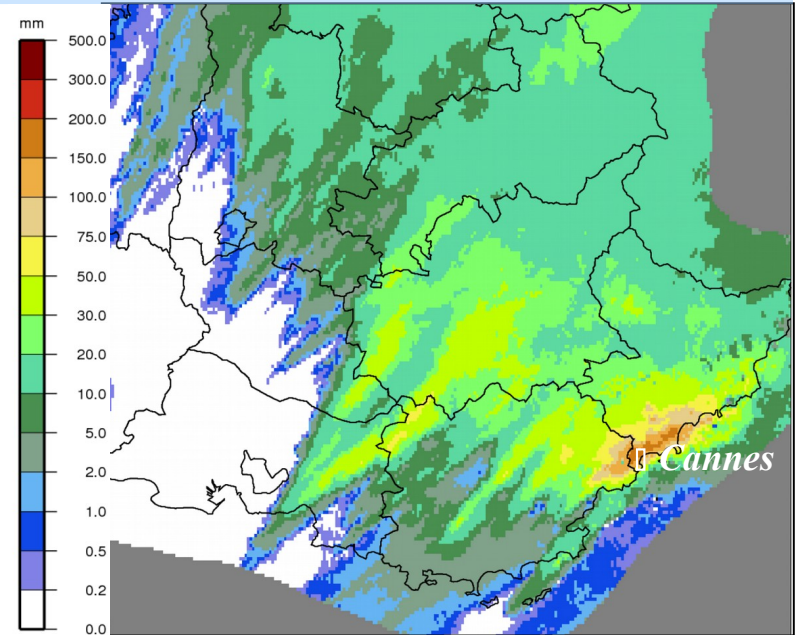
Hourly rainfall in Cannes (mm) from 01/10/2015@00UTC to 04/10/2015@12 UTC



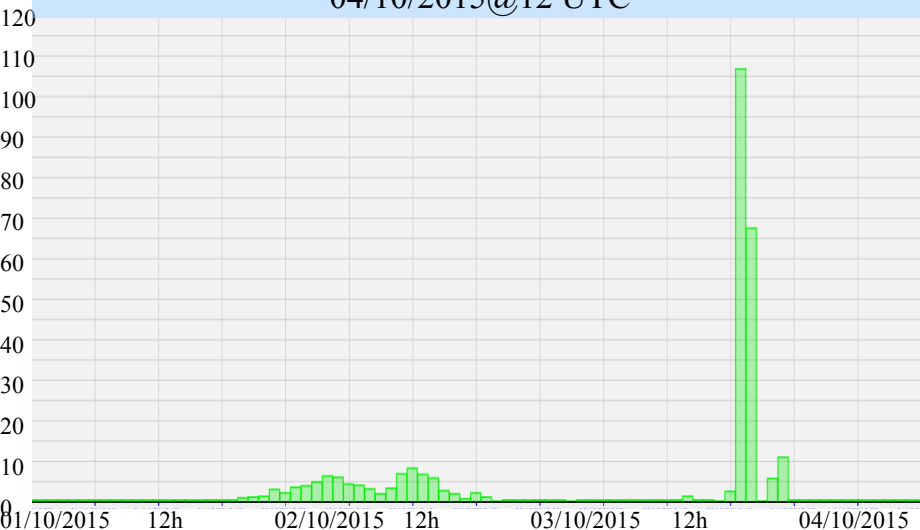
- Small catchments (200 – 2500 km²)
- Steep-sided valleys
- Short lag-time (<12 hrs)

Mediterranean Flash-Floods

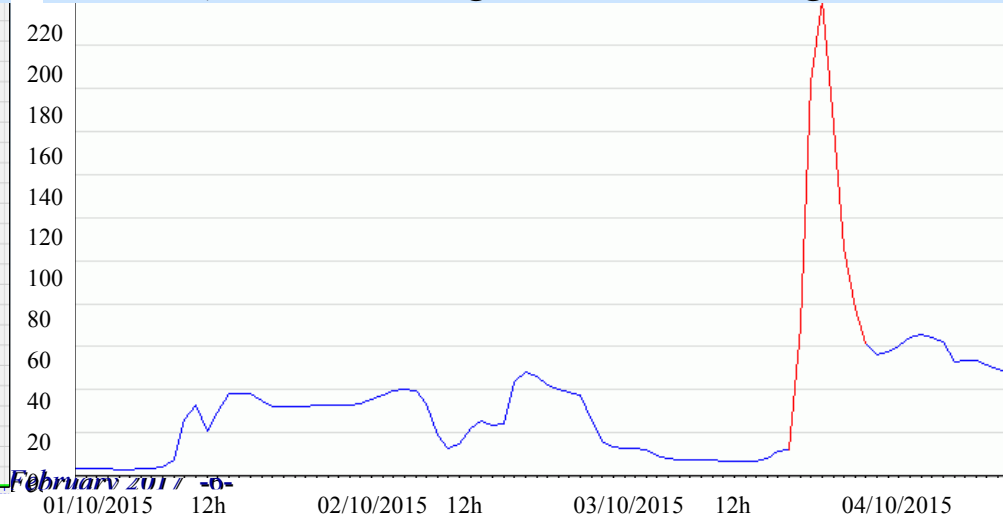
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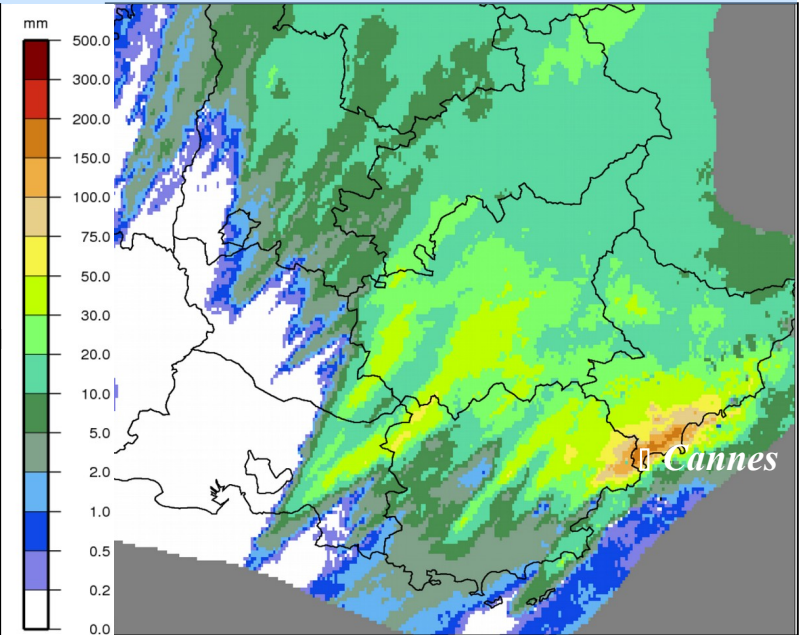


Hourly discharge ($\text{m}^3 \cdot \text{s}^{-1}$) of the Siagne River at Pegomas (near Cannes) from 01/10/2015@00UTC to 04/10/2015@23 UTC

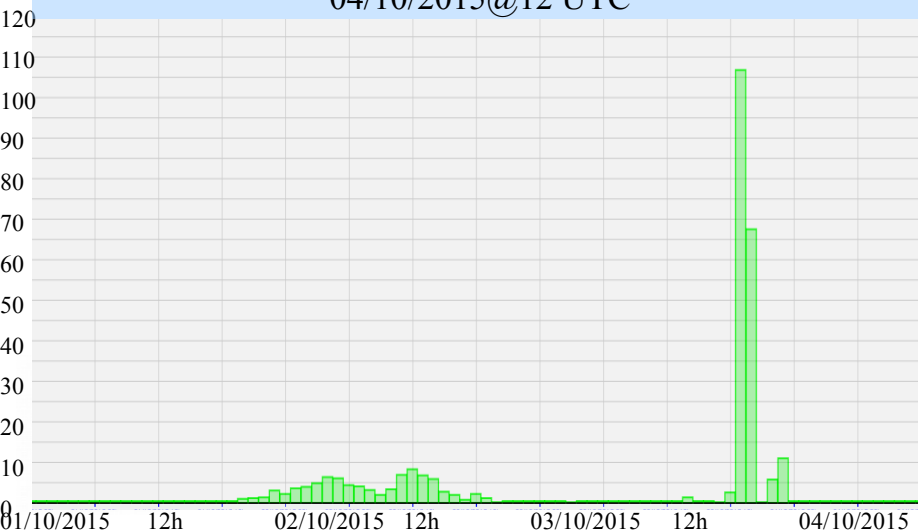


Mediterranean Flash-Floods

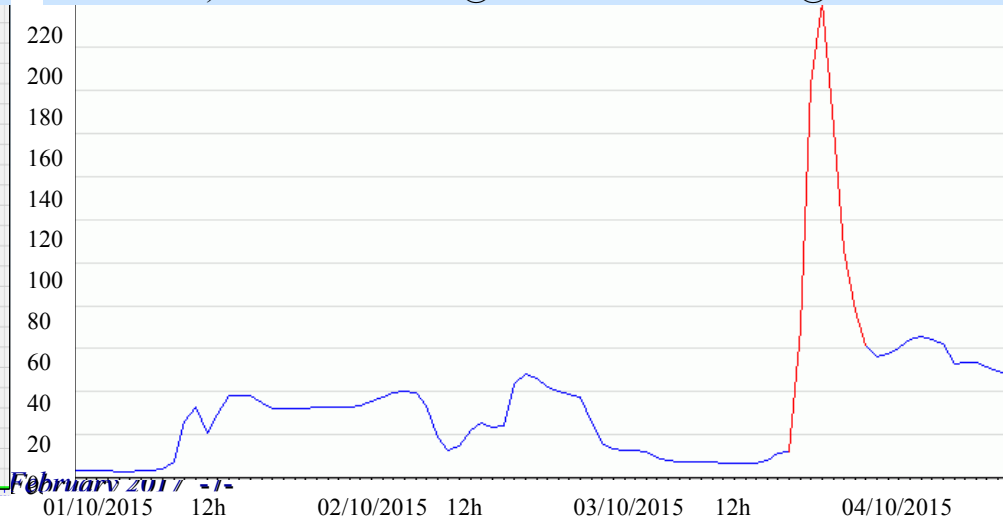
3h-accumulated rainfall (mm): 03/10/2015(17-20 UTC)



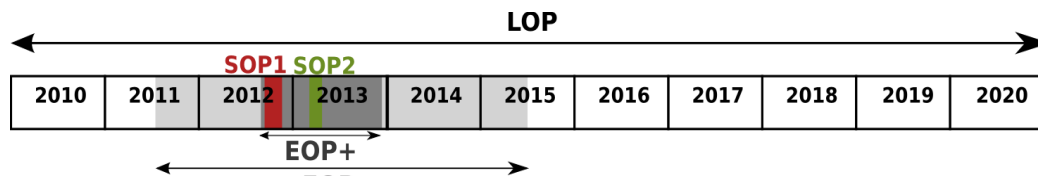
Hourly rainfall in Cannes (mm) from 01/10/2015@00UTC to 04/10/2015@12 UTC



Hourly discharge ($\text{m}^3 \cdot \text{s}^{-1}$) of the Siagne River at Pegomas (near Cannes) from 01/10/2015@00UTC to 04/10/2015@23 UTC



- **HYMEX** (*HYdrological cycle in the Mediterranean Experiment*)
- Aim : better knowledge of **Mediterranean water cycle** to improve the forecasting of **high-impact weather events** (heavy precipitation events HPE, flash flood events FFE)
- Interdisciplinary program : atmosphere/ocean/hydrology
- Embedded observing strategy



LOP = Long Observing Period

EOP = Enhanced Observing Period

SOP = Special Observing Period

IOP=Intensive Observing Period

- Hydrological activities :
 - Observation / modeling / FF forecasting
 - SOP1 :
 - dedicated to HPE and FFE
 - from 05 sept. to 06 nov. 2012
 - 20 IOPs
 - More than 200 deployed instruments
 - EOP + : every fall from 2011 to 2015

Outline

- Context : Mediterranean FF forecasting
- ISBA-TOP option in SURFEX
- ISBA-TOP in an Hydrological Ensemble Prediction System (HEPS)
- Conclusion and future work

ISBA-TOP* option in SURFEX

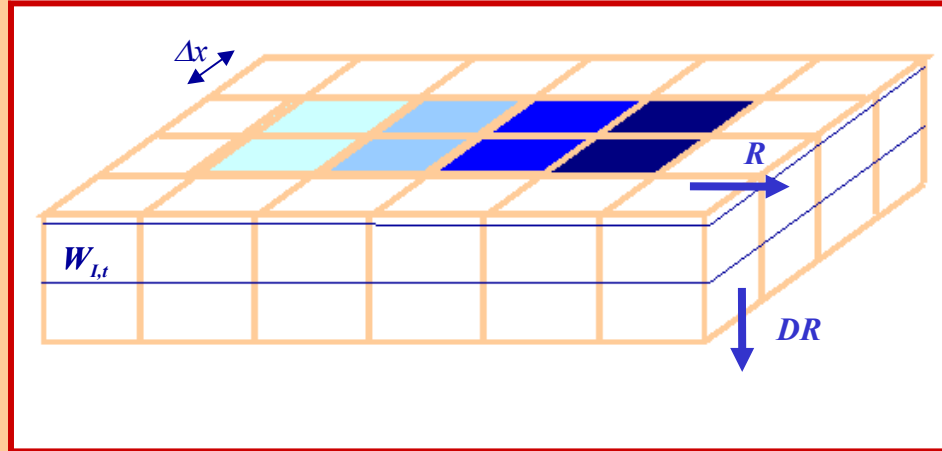
- Sub-surface lateral water fluxes crucial in FF generation *Bouilloud et al., 2010

Vincendon et al.,
2010, 2016

ISBA ∈ SURFEX

(Noilhan and Planton 1989)

- Water and energy balance
- Surface/atmosphere interactions
- Vertical soil columns
- ISBA-3L/ISBA-DF
- Cover : ECOCLIMAP
- Soil textures : HSWD
- $\Delta x = 1\text{km}$
- $\Delta t = 15\text{min}$



ISBA-TOP* option in SURFEX

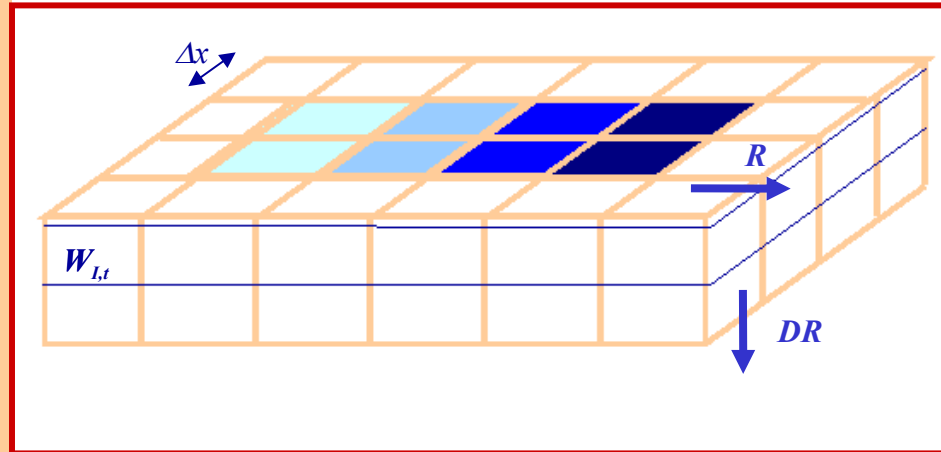
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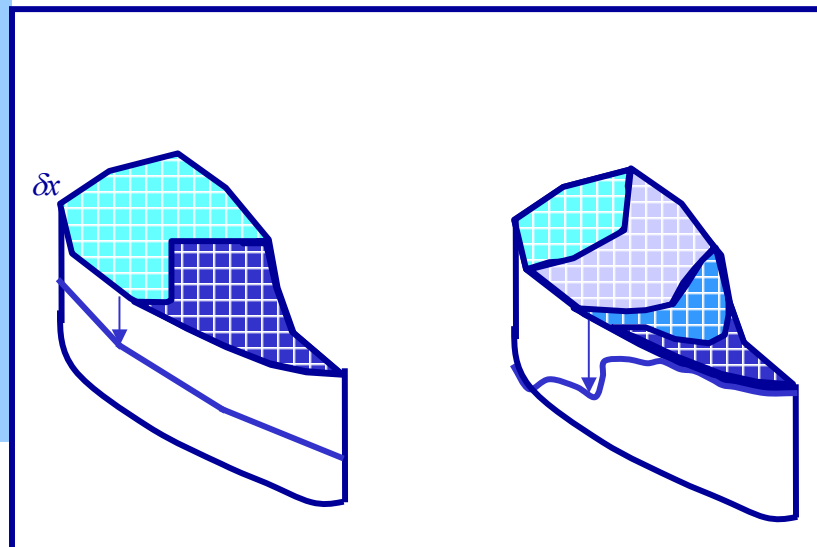
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TOPMODEL

(Beven and Kirkby 1979)

- Lateral soil moisture distribution on the watersheds
- Based on information on topography
- TOPODYN (Pellarin et al., 2002)
- DTM : $\delta x = 50\text{m}$
- $\delta t = 1\text{h}$



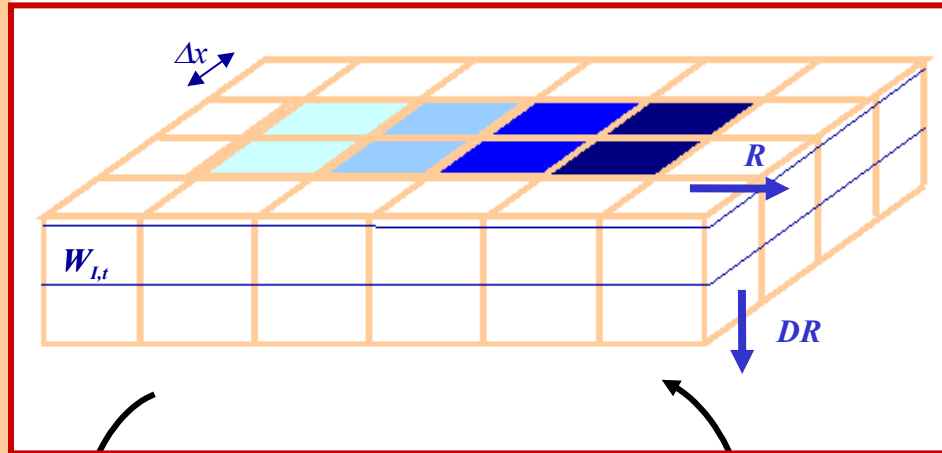
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Soil moisture

New soil moisture

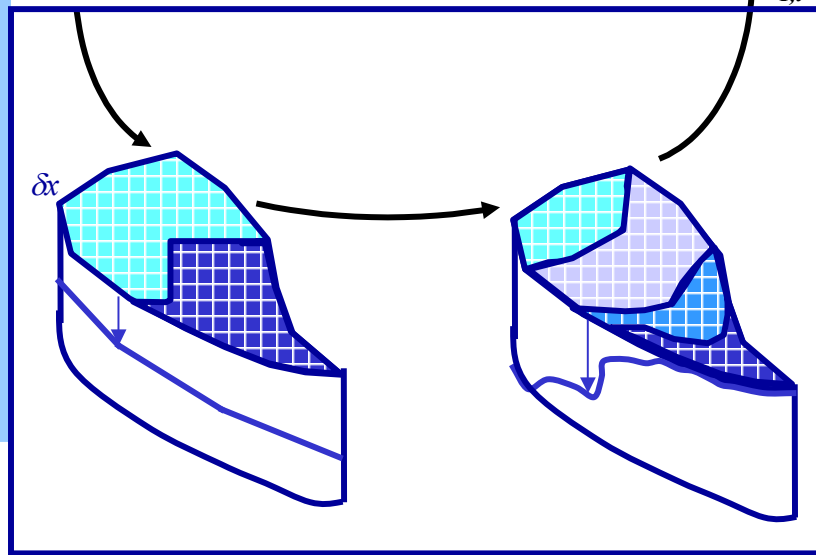
$W_{l,t}$

$W'_{l,t}$

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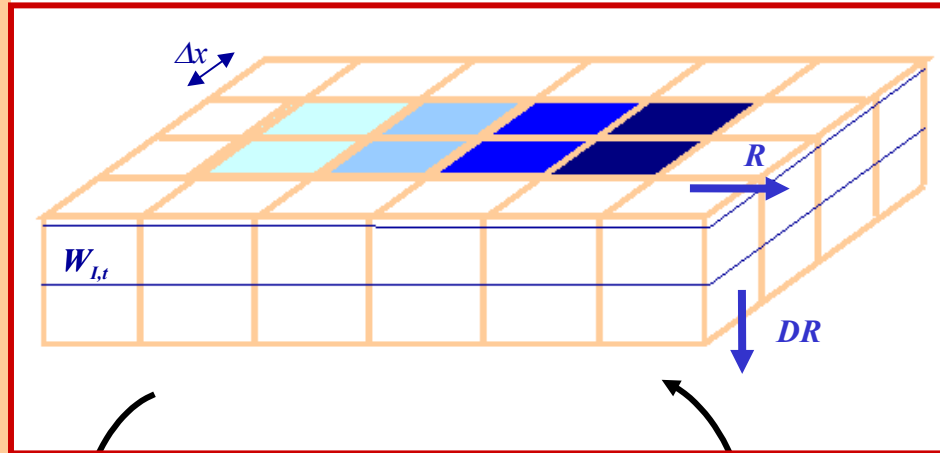
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Runoff R
Drainage DR

Soil moisture

$W_{l,t}$

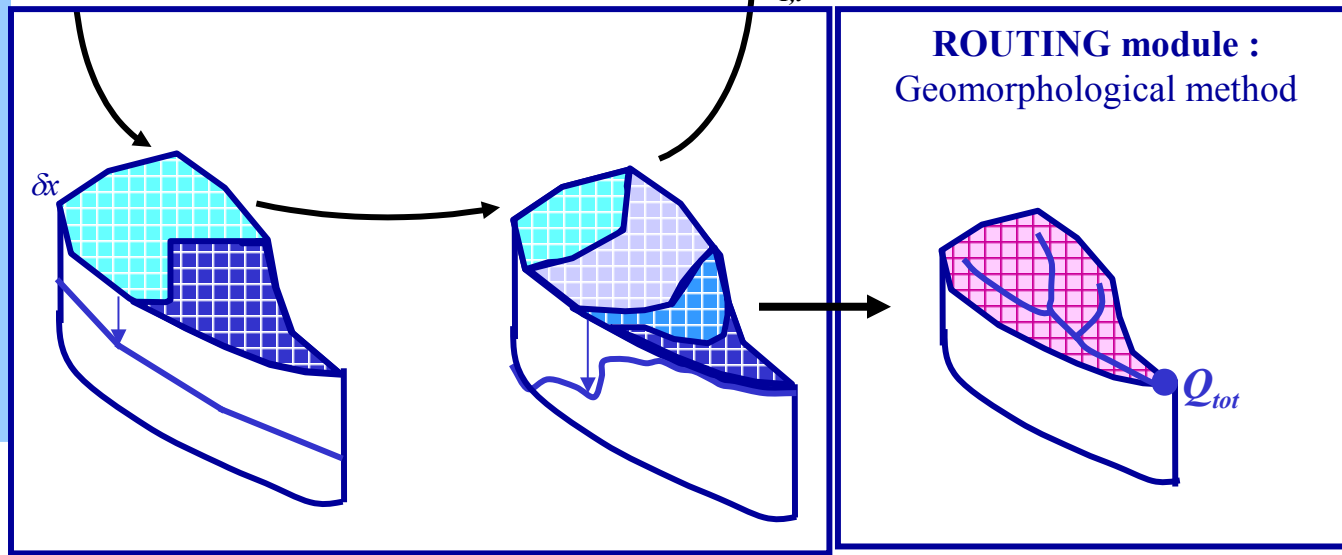
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ROUTING module :
Geomorphological method

Q_{tot}

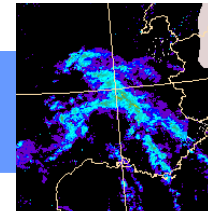
FF simulations from meteorological observations

Atmospheric Forcing

2-m air temperature and humidity
10-m winds
Long and short wave radiations
Surface pressure

Precipitation

Radar estimates
QPE (1km x 1km)

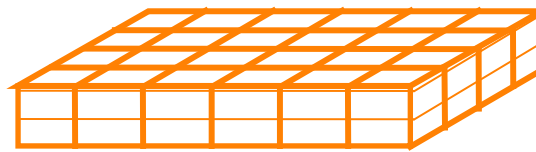


SAFRAN

Initial soil
conditions

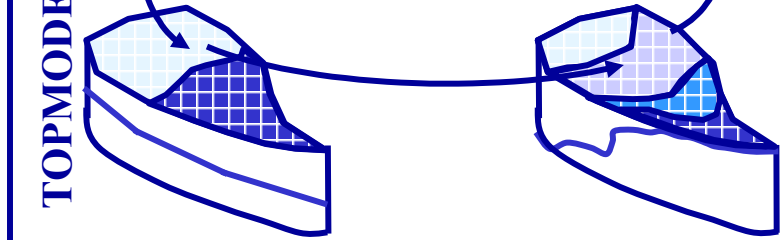
Moisture
Temperature
SIM

ISBA

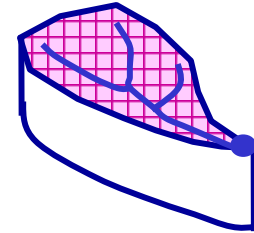


ISBA-TOP

TOPMODEL

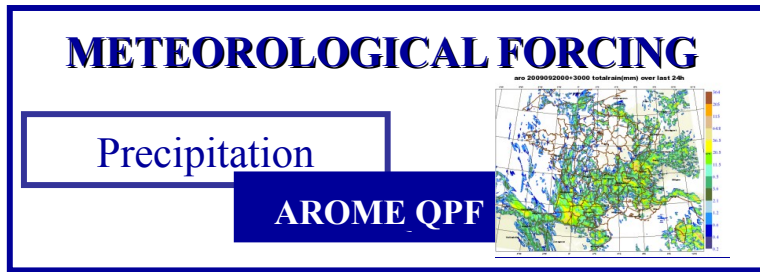


ROUTING
MODULE:



Hourly discharges

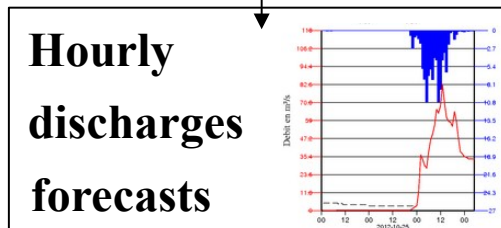
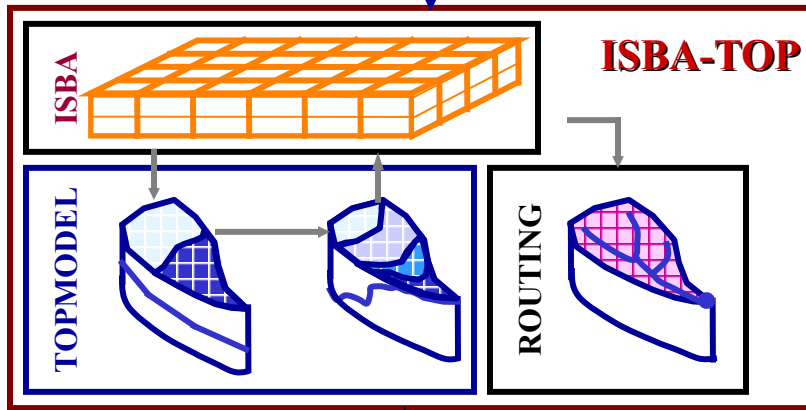
The hydrometeorological forecasting chain



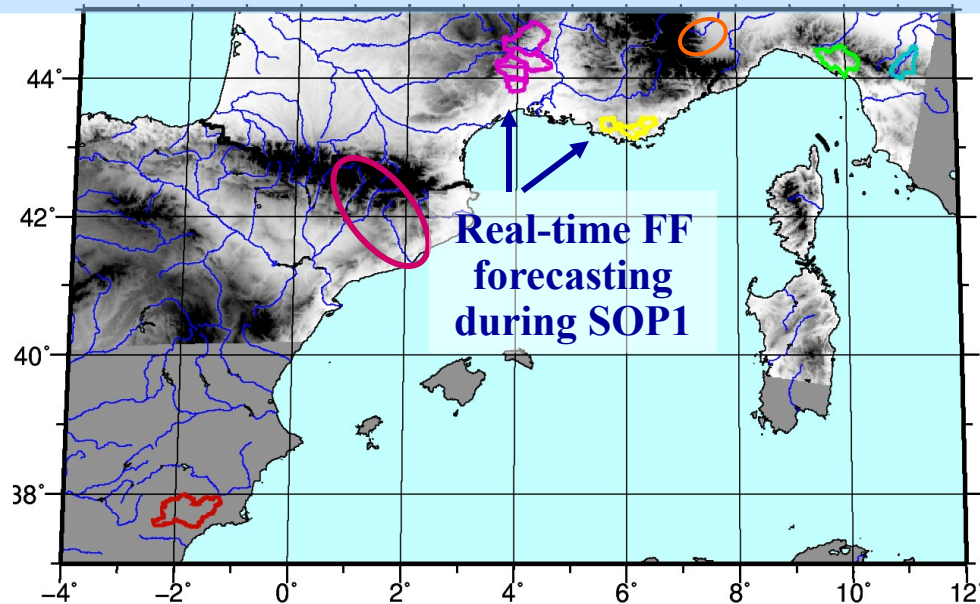
➤ AROME #

Seity et al, 2011
*Fourrié et al, 2015

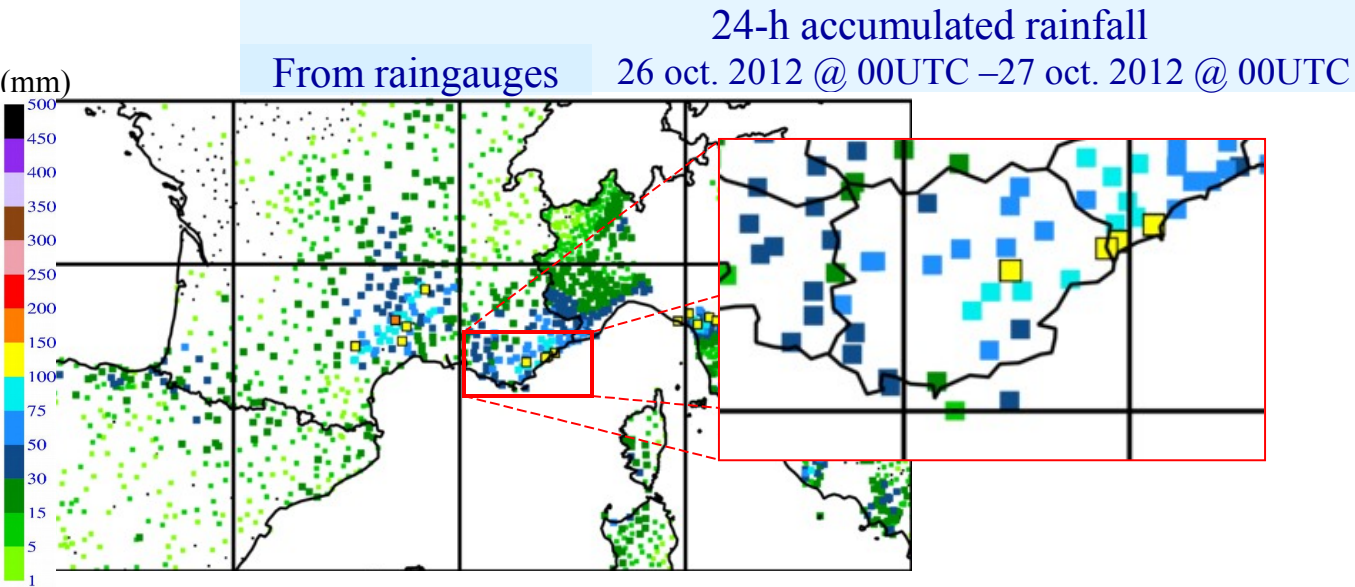
- convection permitting
- 2.5-km resolution
- WMed* version



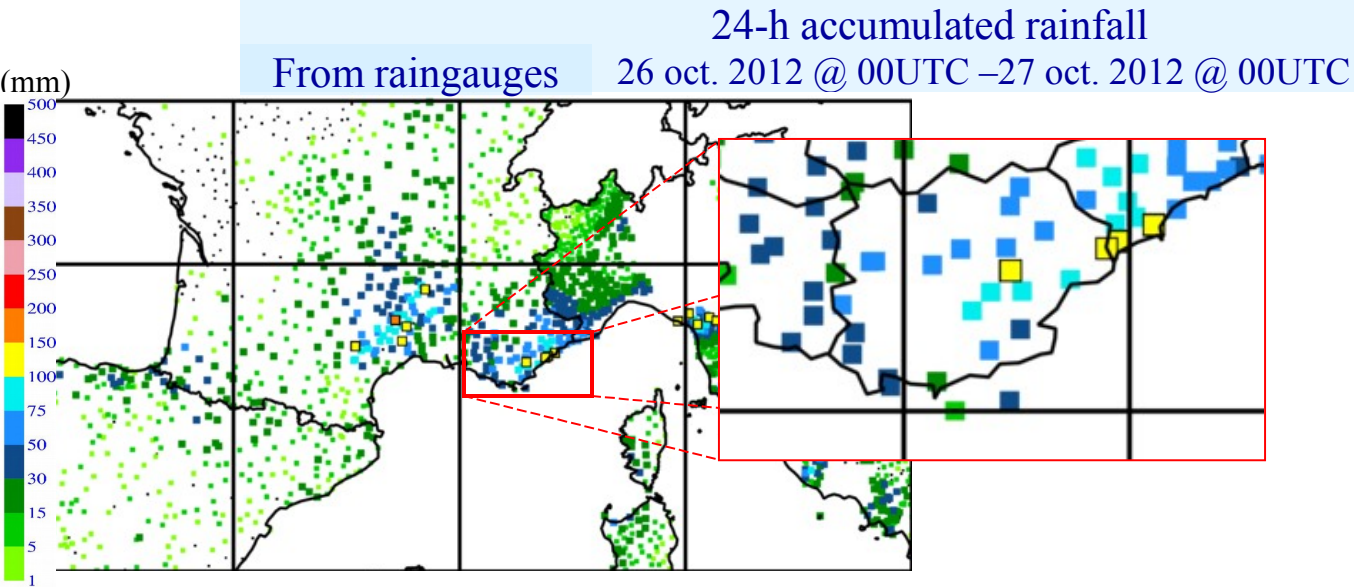
Watersheds where ISBA-TOP has been used within HYMEX



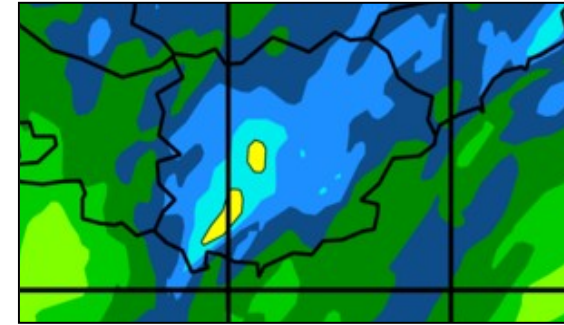
Example of result : IOP16a on the Var area



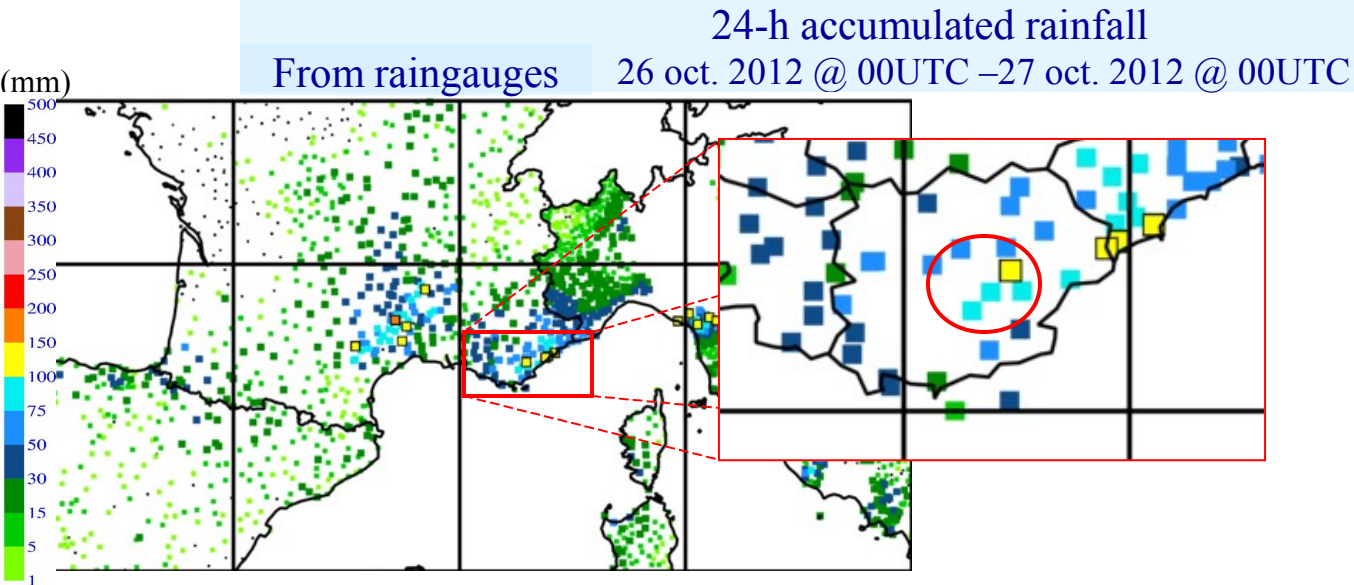
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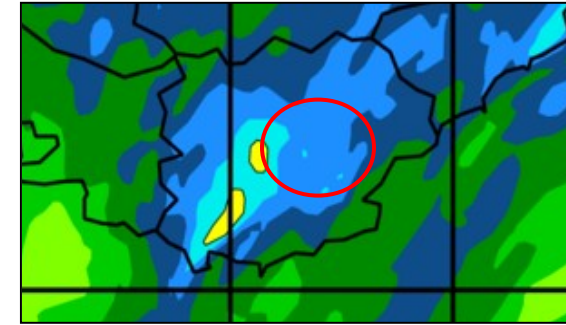
From AROME-WMED forecast
(starting 26/10 at 00UTC)



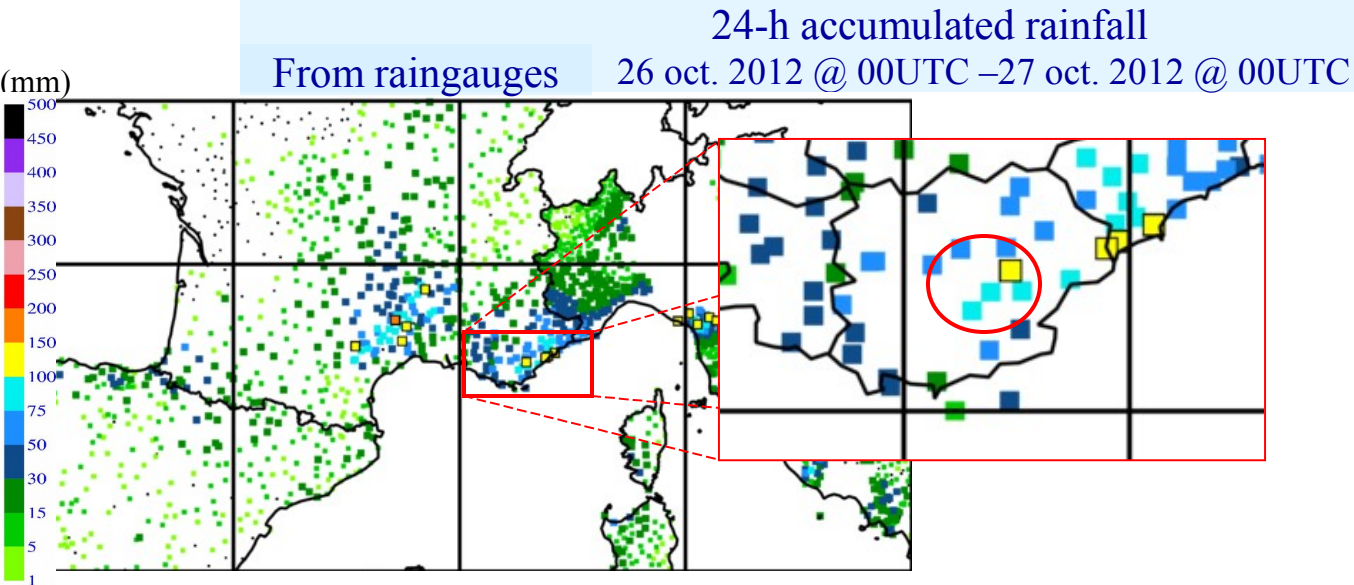
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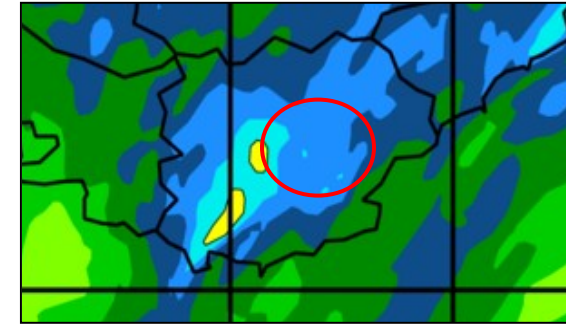
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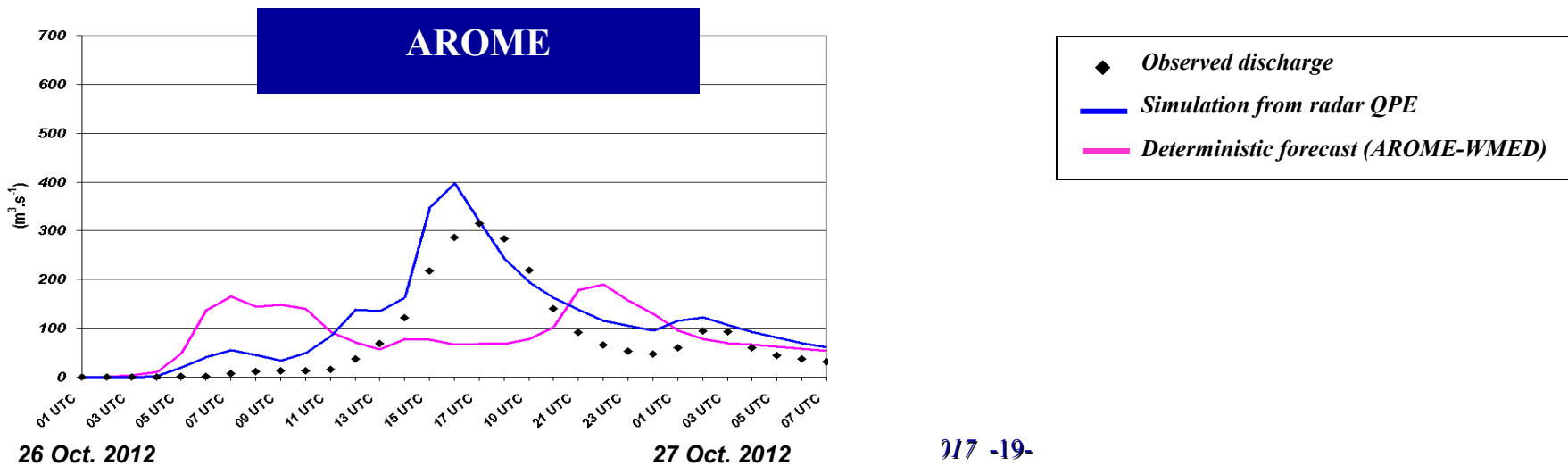
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From AROME-WMED forecast
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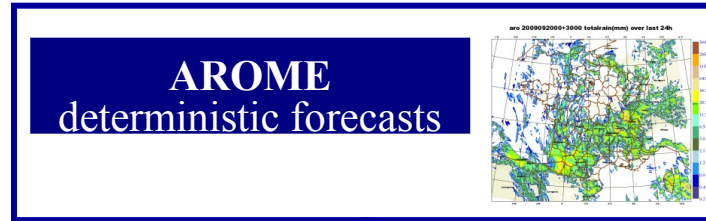
1h-QDF forecasts for Aille River at Vidauban
26 oct. 2012 @ 00UTC – 27 oct. 2012 @ 06UTC



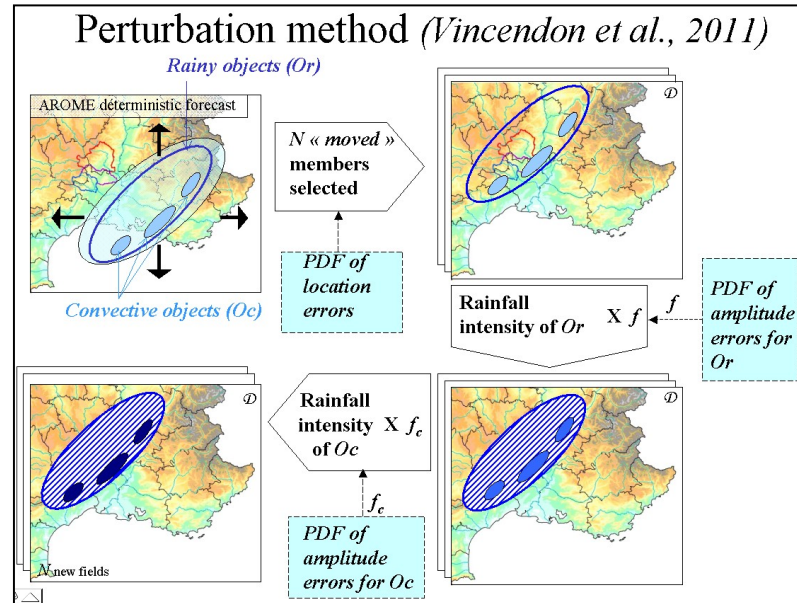
From deterministic to ensemble forecasting : an HEPS design



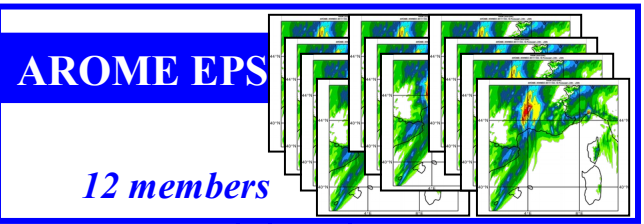
From deterministic to ensemble forecasting : an HEPS design



2



2

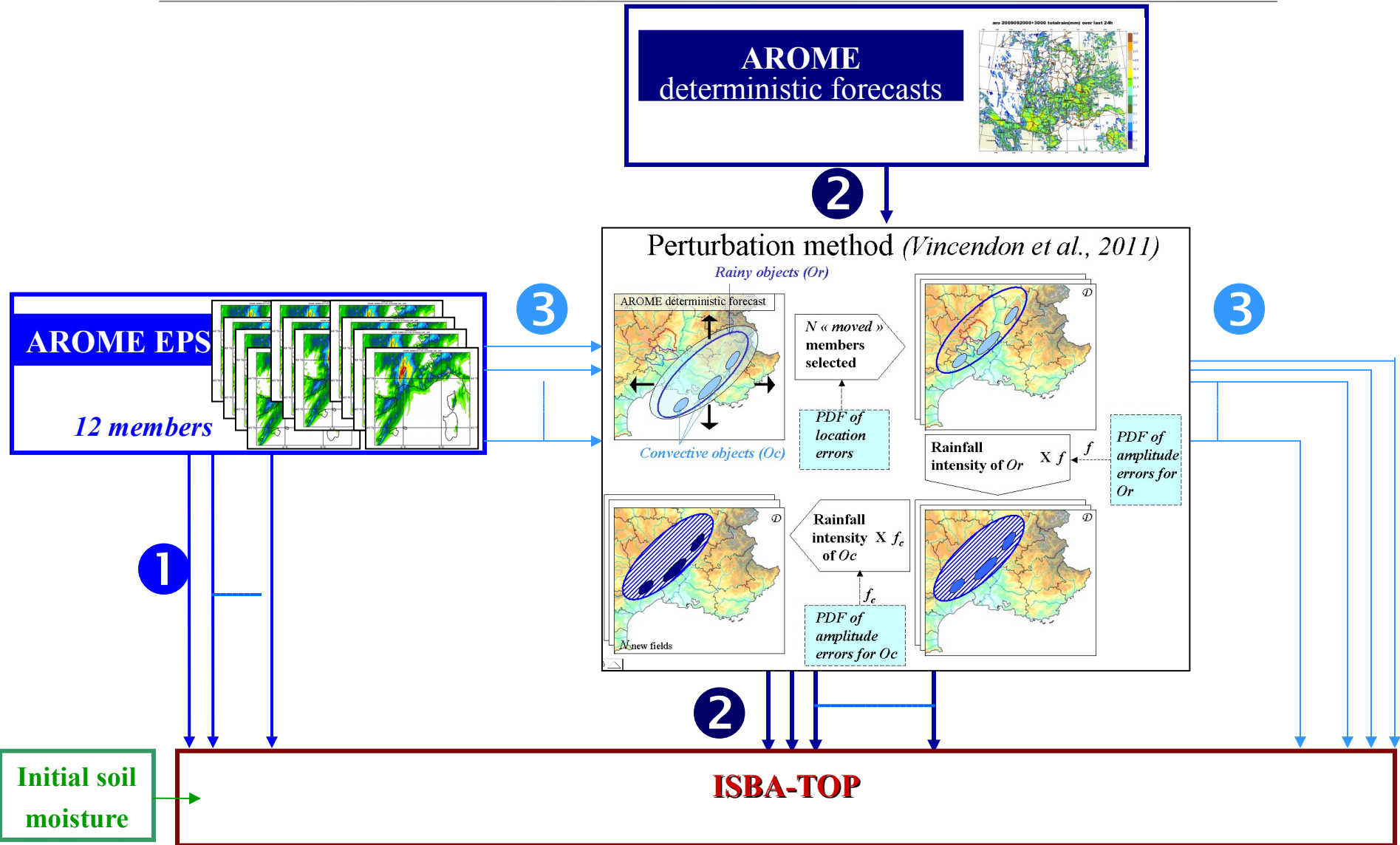


1

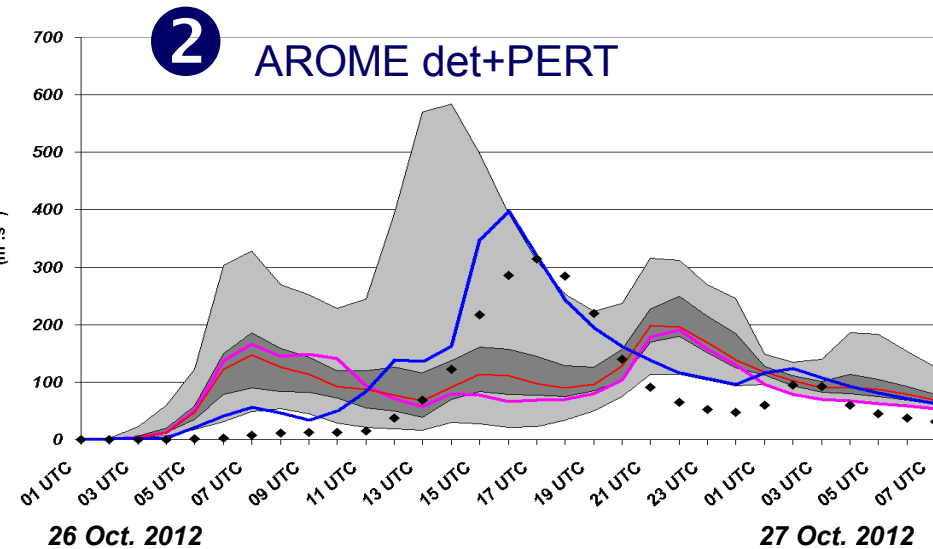
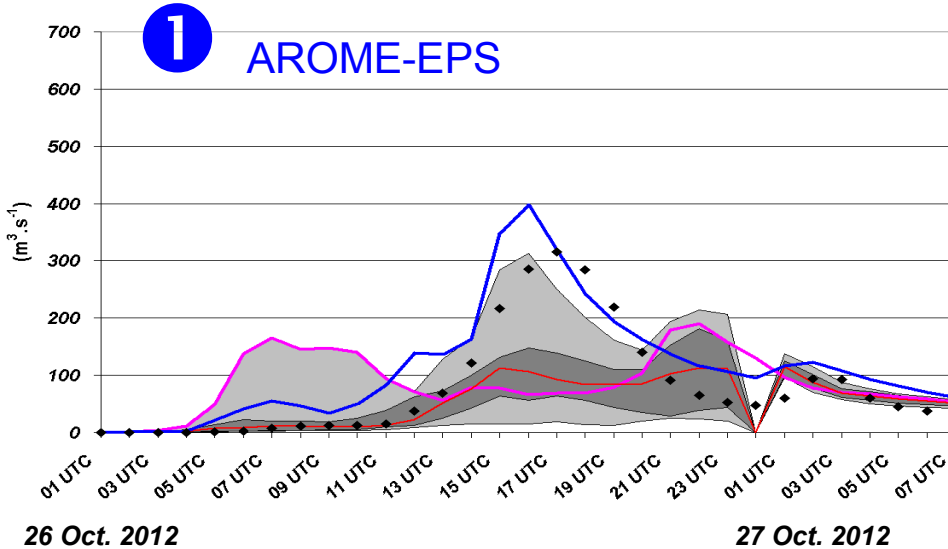
Initial soil moisture



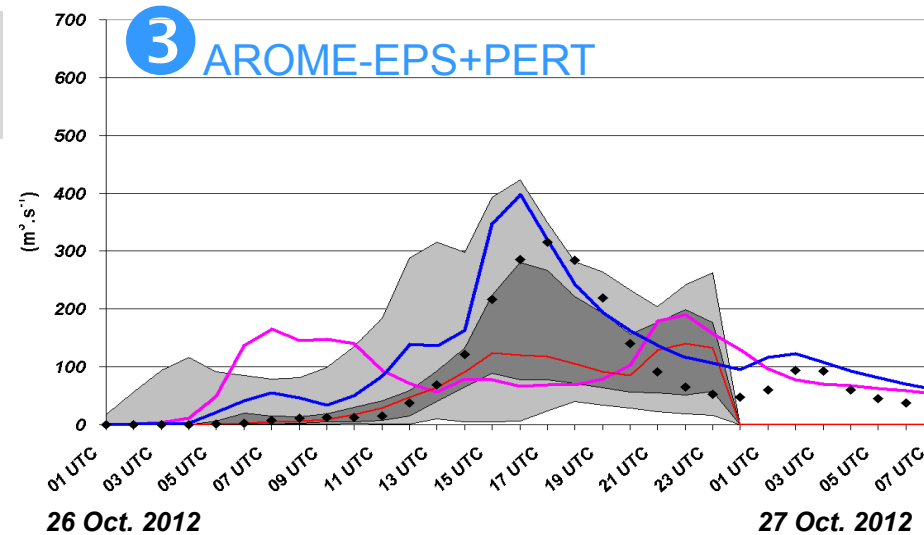
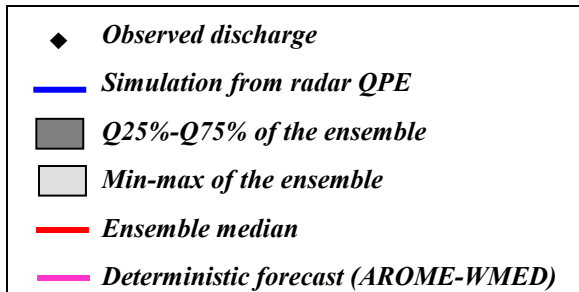
From deterministic to ensemble forecasting : an HEPS design



From deterministic to ensemble forecasting : an HEPS design



Discharge ensemble for Aille River at Vidauban :
26 oct. 2012 @ 02UTC – 27 oct. 2012 @ 07UTC



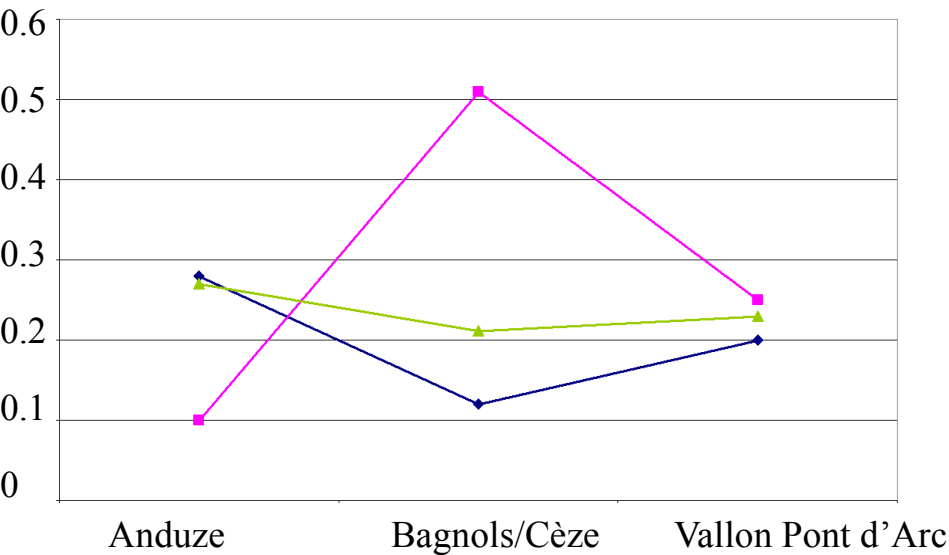
From deterministic to ensemble forecasting : an HEPS design

Probabilistic scores for all the events of the fall 2014 for the 3 HEPS

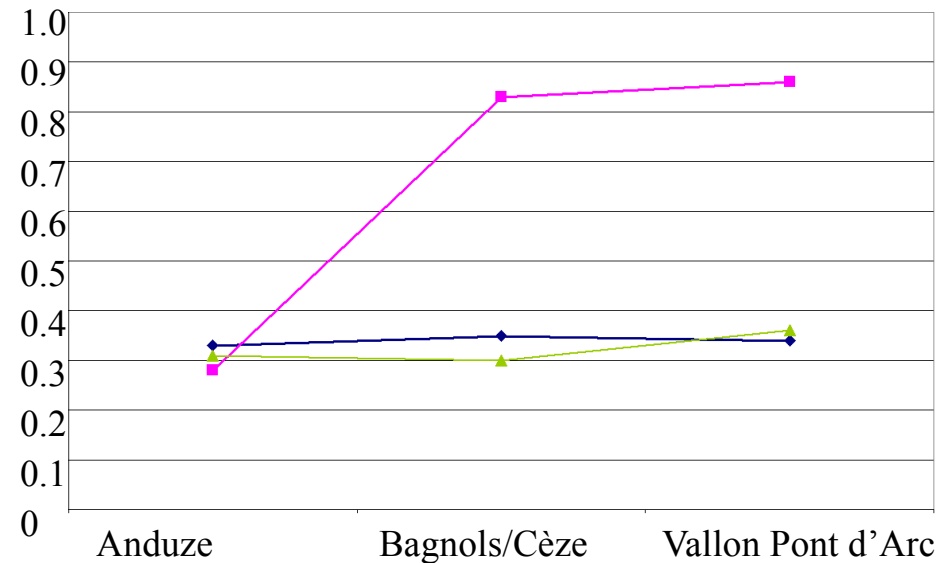
- ① AROME-EPS
- ② AROME det+PERT
- ③ AROME-EPS+PERT

RPSS

(ref = deterministic AROME QPF driving ISBA_TOP)



Sigma/RMSE

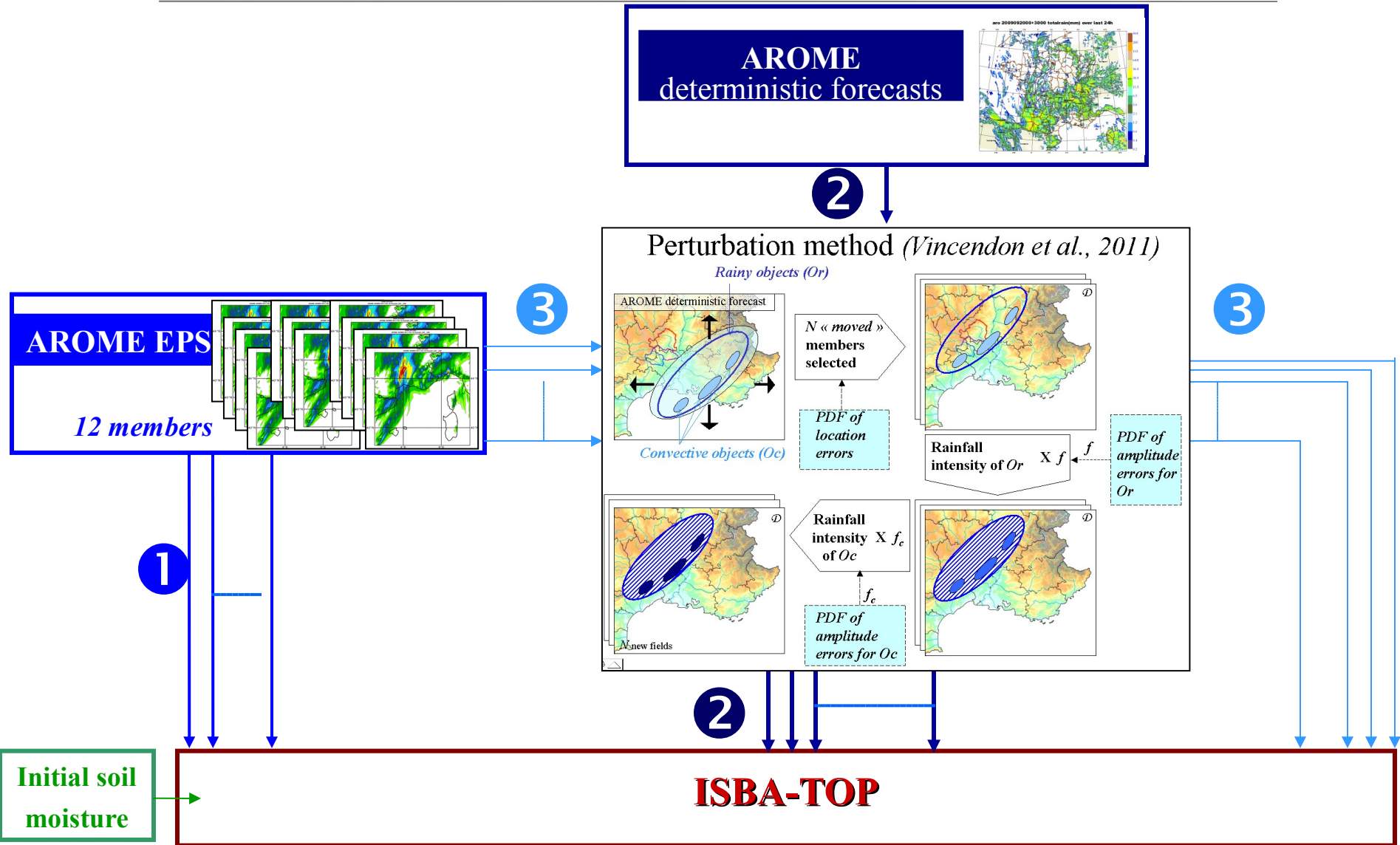


➤ Perturbing the AROME-EPS members :

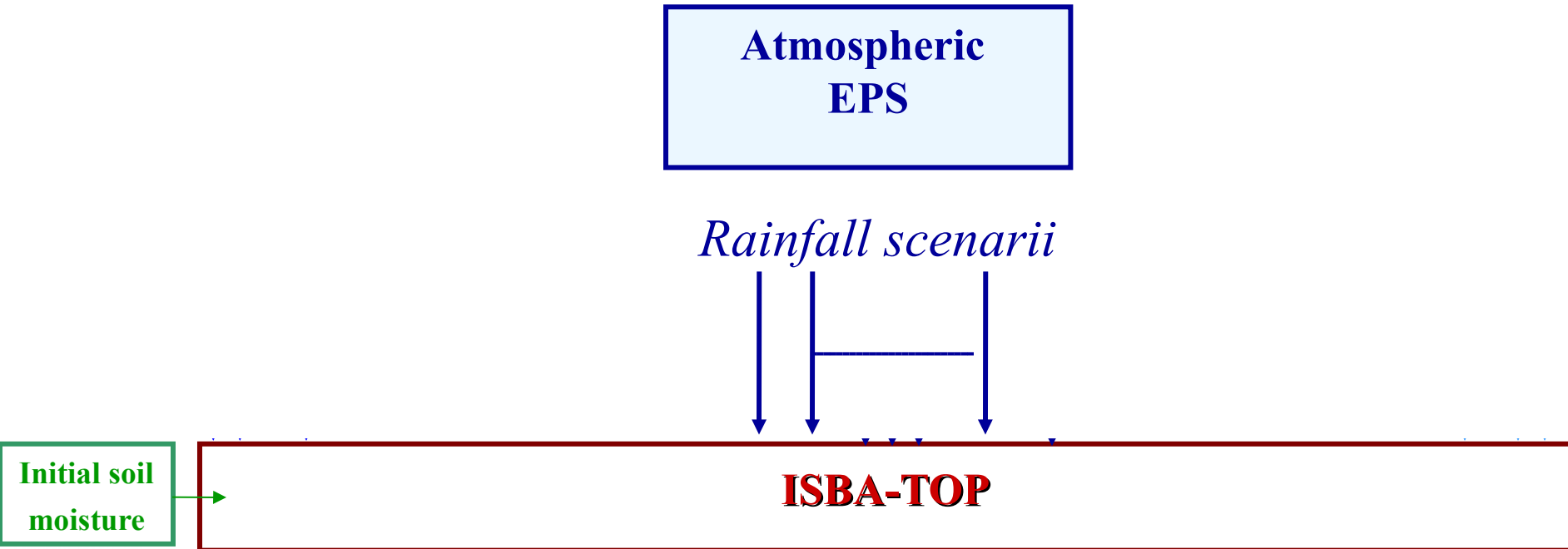
⇒ Better spread

⇒ RPSS still positive, slightly higher

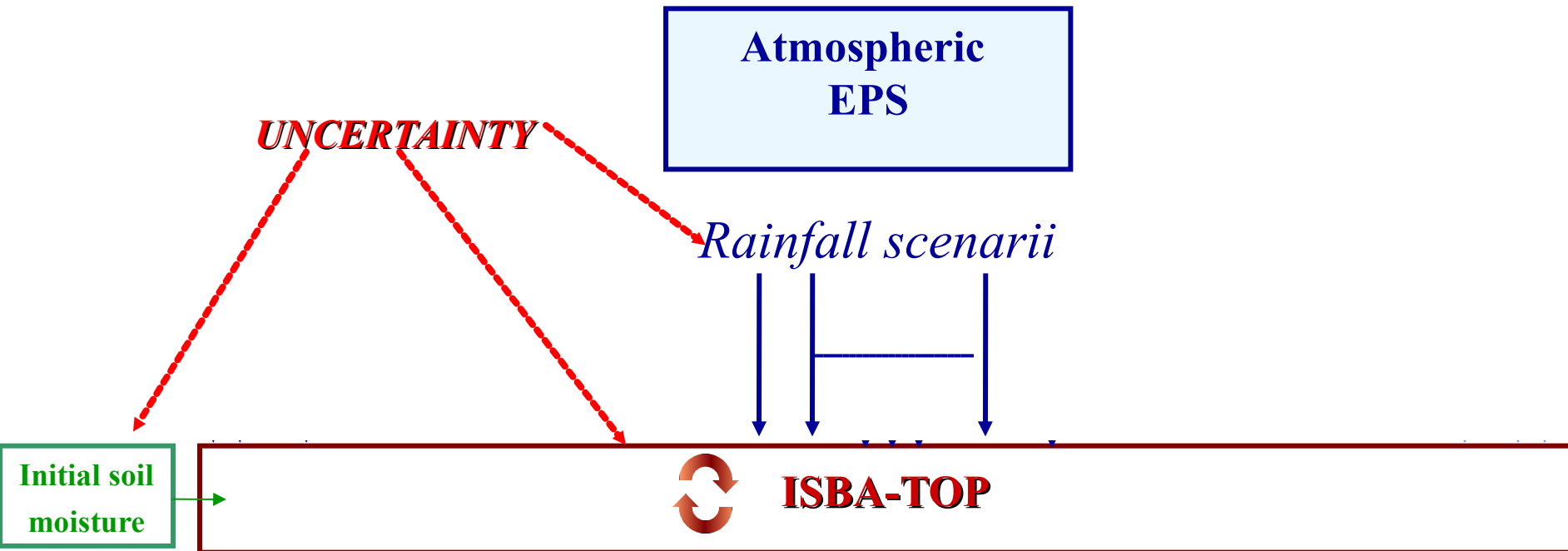
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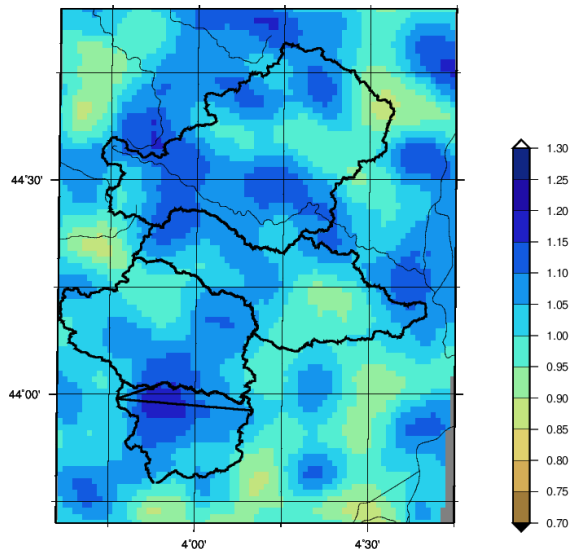
From deterministic to ensemble forecasting : an HEPS design



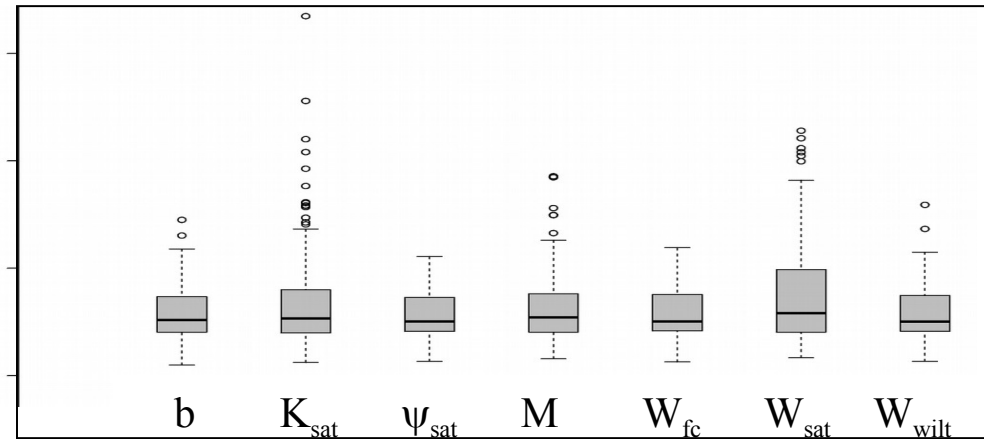
Uncertainty on the hydrological modelling and initial soil moisture

- Sensitivity study of ISBA-TOP
 - ⇒ Method to perturb the ISBA-TOP :
 - most sensitive parameters
 - initial soil moisture
- (Édouard *et al.*, under review)

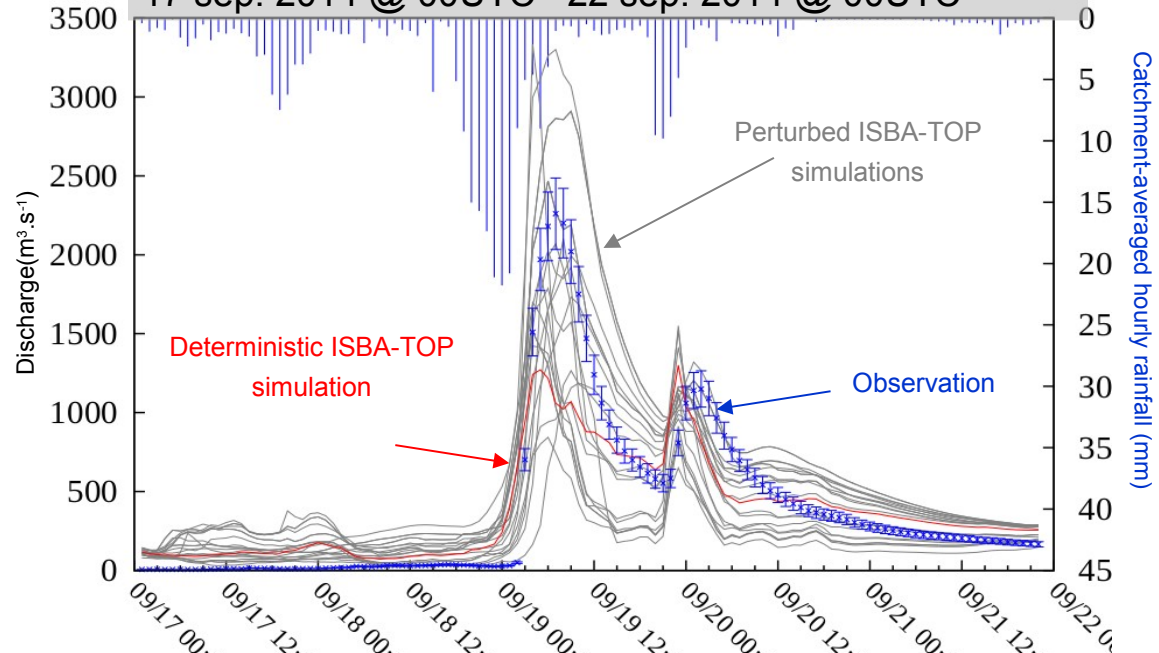
Example of smoothed random coefficients map used to perturb the initial soil moisture fields.



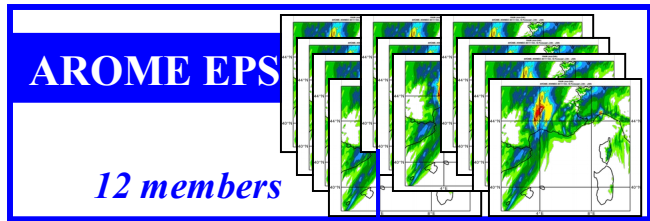
Mean Absolute errors (%) on 1h-discharge for 6 events on 4 catchments varying hydrodynamical parameters



1-h discharge of the Ardèche River at Vallon-Pont-d'Arc 17 sep. 2014 @ 00UTC –22 sep. 2014 @ 00UTC



An HEPS considering several sources of uncertainty



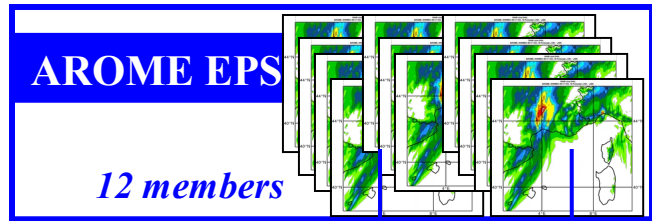
4



Perturbed
initial soil
moisture
conditions

ISBA-TOP
with a
perturbed set
of parameters

An HEPS considering several sources of uncertainty



4

ISBA-TOP
pert

ISBA-TOP
pert

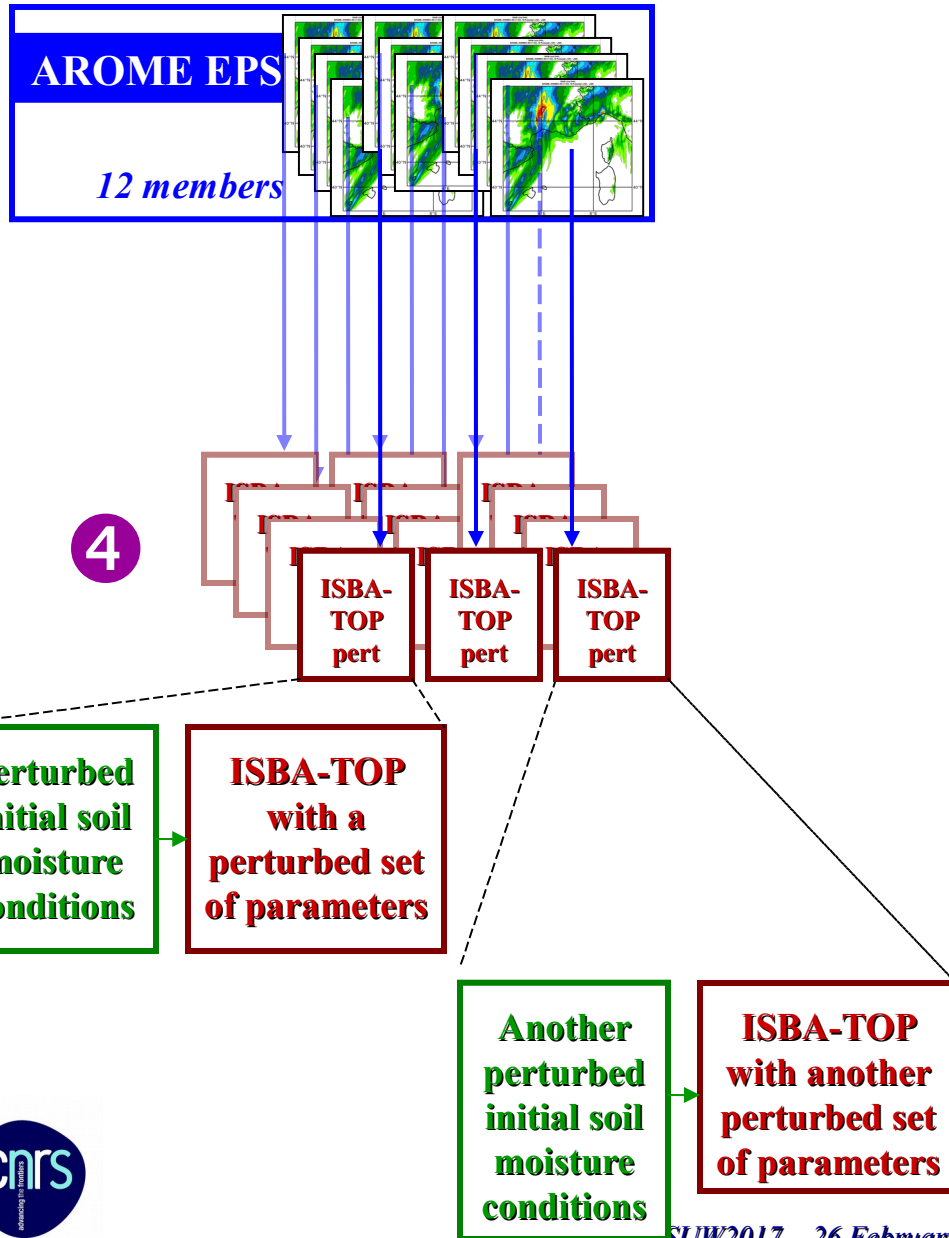
Perturbed
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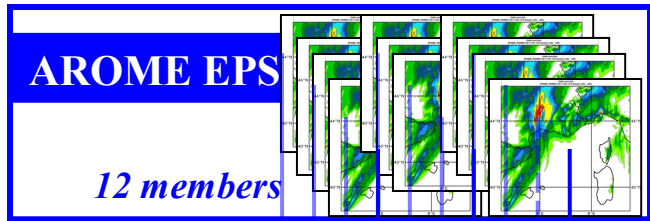
Another
perturbed
initial soil
moisture
conditions

ISBA-TOP
with another
perturbed set
of parameters

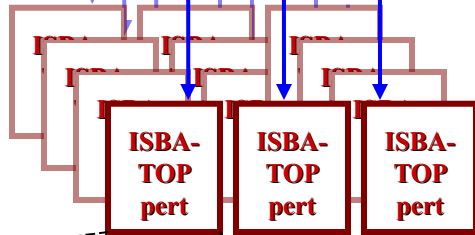
An HEPS considering several sources of uncertainty



An HEPS considering several sources of uncertainty



4

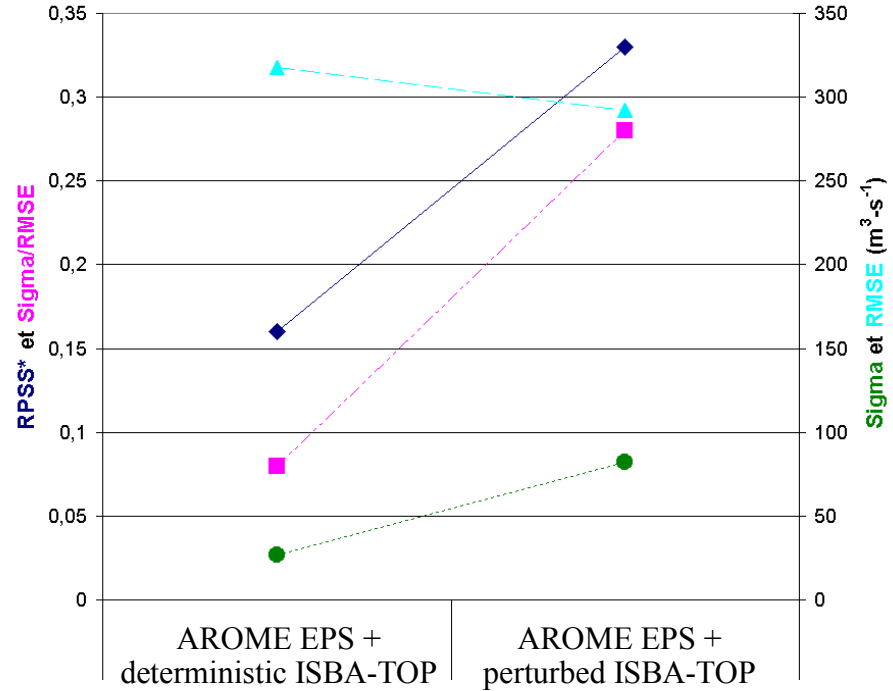


Perturbed initial soil moisture conditions

ISBA-TOP with a perturbed set of parameters

Another perturbed initial soil moisture conditions

ISBA-TOP with another perturbed set of parameters



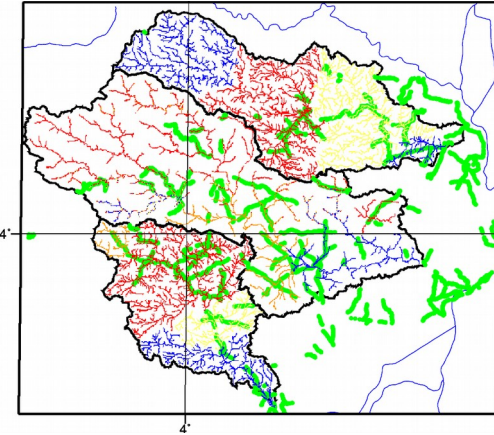
1

4

Scores for HEPS 1 and 4 for events of the fall 2014.
(ref = deterministic AROME QPF driving ISBA_TOP)

Conclusion and future work

Severity map on 3-7 September 2002 on Cévennes catchments



➤ Conclusions:

- ISBA-TOP in SURFEX :
 - to better simulate Mediterranean FF
 - specific diagnostics developed
- ISBA-TOP used in an HEPS considering the uncertainty on :
 - QPF (real time chain within Hymex SOP1)
 - the hydrological model parameters and initial soil moisture.
- ISBA-TOP used to assess from an hydrological point of view :
 - ECMWF EPS downscaled by WRF on HYMEX IOP8 (Spain)
 - COSMO-H2 EPS on an Italian catchment for IOP19 of HYMEX
 - AROME EPS on the fall 2014 events

➤ Future work :

- Improvement and assessment of the HEPS
- Use of ISBA-TOP for FF nowcasting purpose

ISBA-TOP in SURFEX

- Option available in SURFEX V8:

*&NAM_SGH_ISBA*_{*n*} *CRUNOFF* = "TOPD",

&NAM_PGD_TOPD *CCAT*(1) = "NameOfCatchment",
LCOUPL_TOPD=T, ...

&NAM_TOPD *NNB_TOPD*=4, ...

- Next version :
 - Discretization in sub-catchments (*LSUBCAT*=T)
 - Variable water velocity in the river (*Artinyan et al., 2016*)
 - Perturbation of hydrodynamical parameters and initial soil moisture field

Thank you

Artinyan et al, 2016: Artinyan, E., Vincendon, B., Kroumova, K., Nedkov, N., Tsarev, P., Balabanova, S. and Koshinchanov, G. : Flood forecasting and alert system for Arda River basin, *J. Hydrology*, in press.

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