Usefulness of radar QPE for Mediterranean flash-flood ensemble forecasting

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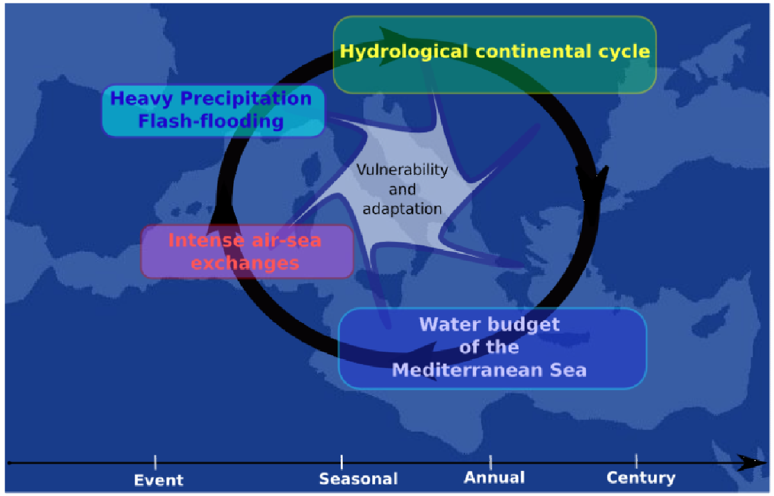
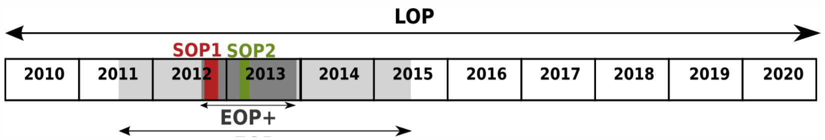
ERAD 2012 - Toulouse –28 June 2012

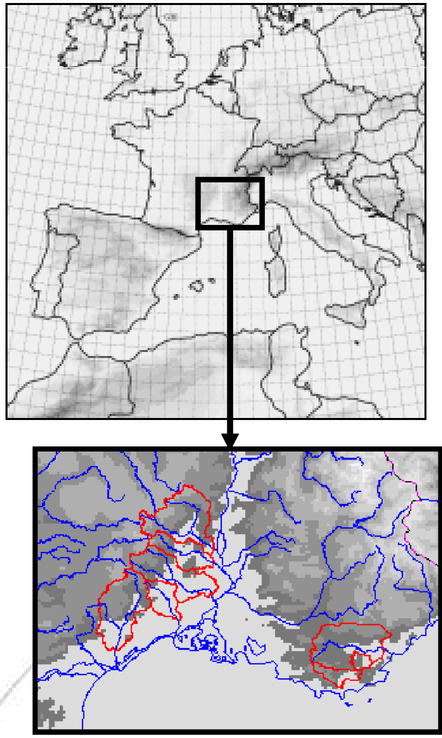
HYdrological cycle in the **M**editerranean **Ex**periment

HyMeX



- Aim : understanding of the **water cycle** with emphases on **intense events**
- « Time-nested » observation stategy :

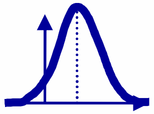




- First HYMEX Special Observation Period (SOP) :
  - **North-Western Mediterranean**
  - from **5 September to 6 November 2012**
  - dedicated to **Heavy Precipitation Events and FF**.
- Additional observing systems deployed
- Real time meteorological and hydrological forecasting
  - *e.g.* for FF : **ISBA-TOPMODEL**

FF forecasting within HYMEX

*(Seity et al, 2011)



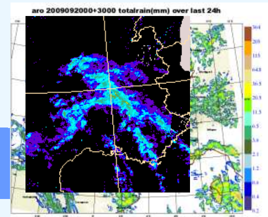
- Uncertainty affects QPF even for high resolution NWP

METEOROLOGICAL FORCING

Precipitation

ARC

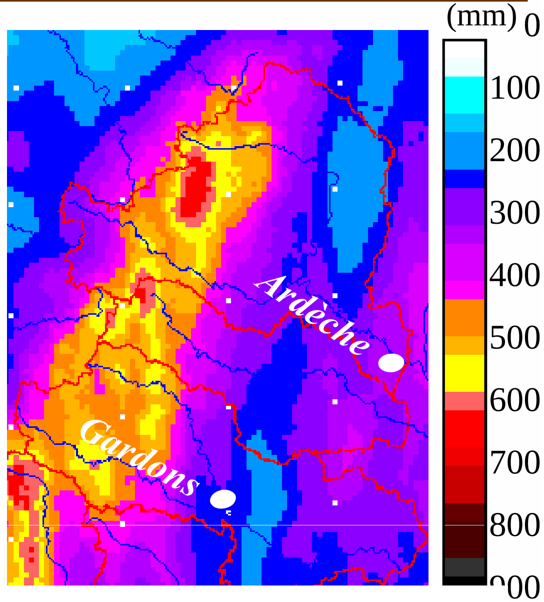
Radar QPE



ISBA-TOPMODEL*

*Bouilloud et al, 2010; Vincendon et al, 2010

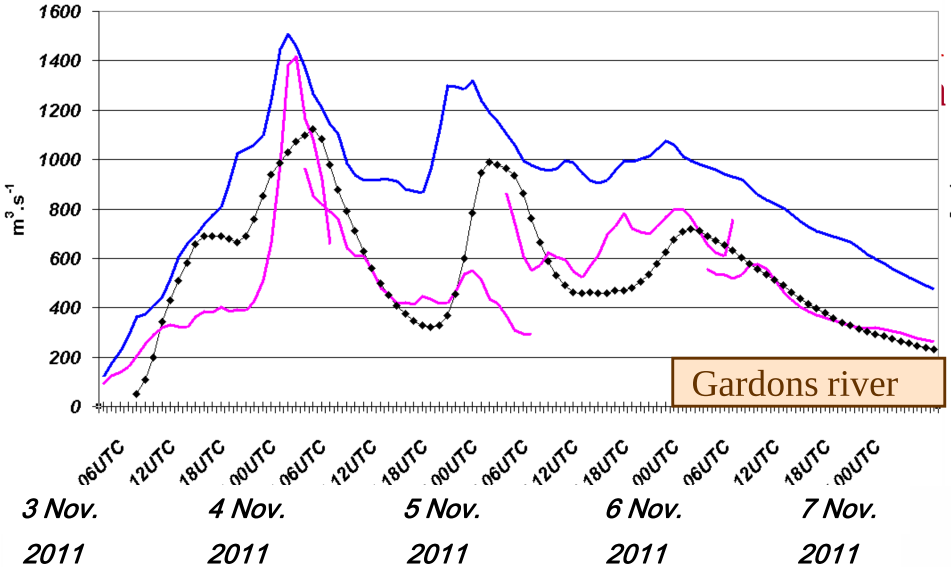
Accumulated rainfall (radar QPE) from 3 Nov. 2011 to 8 Nov. 2011

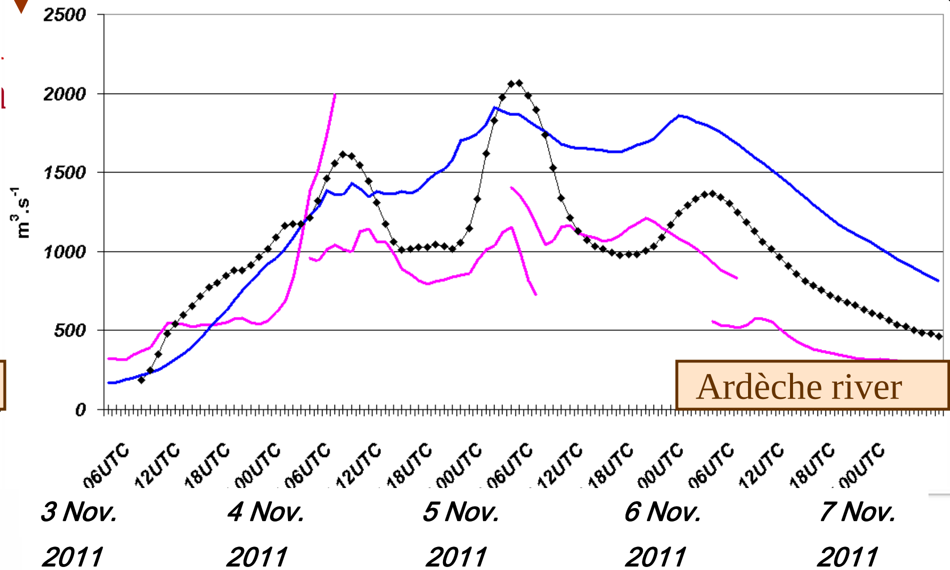


Observation

Simulation driven by radar QPE

Forecast with deterministic QPF

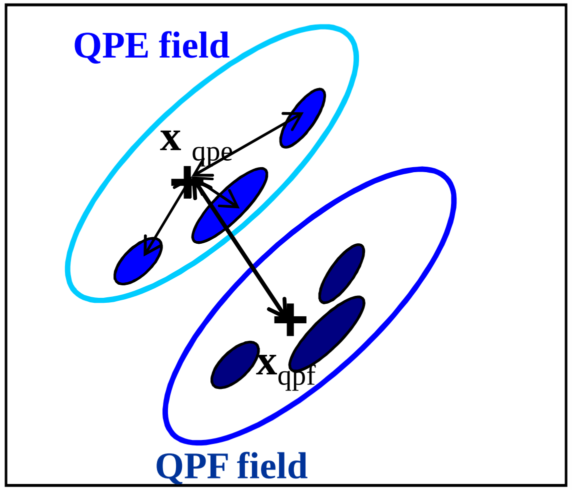




Discharges from 3 Nov. 2011 @ 00UTC to 7 Nov. 2011 @ 00UTC

Assessment of high resolution QPF errors

- Climatology of differences between QPF and radar QPE
- Double penalty problem ⇨ object-oriented climatology of errors
- Objects defined according to thresholds in mm/h in the QPF and QPE fields

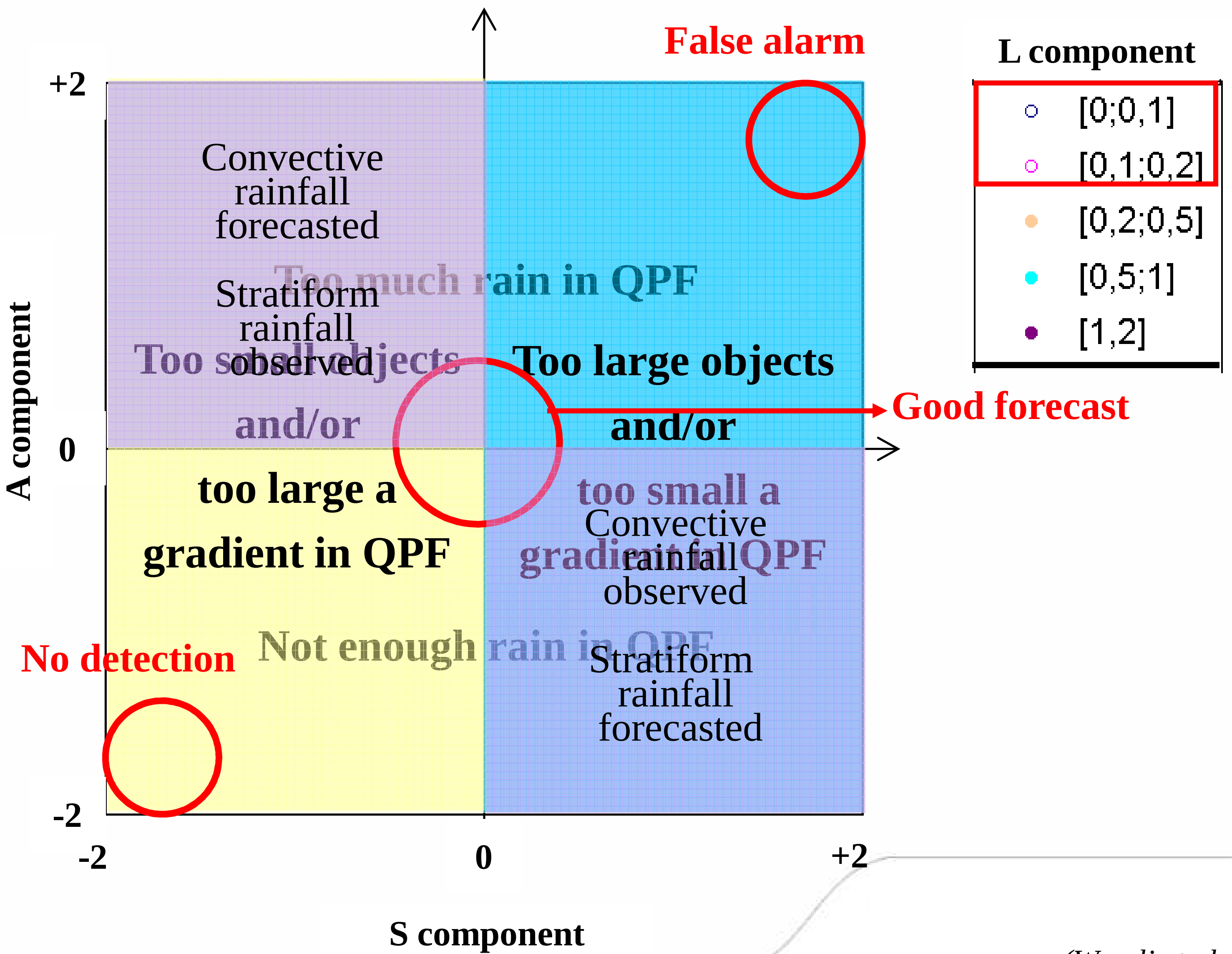


- PDF of **amplitude** and **location** errors
- **S**tructure-**A**mplitude-**L**ocation* method
  - measure of the QPF quality
  - no need to match objects one to one

- **S** : difference in **size , shape and gradient** of the rainy objects
- **A** : normalized difference of **averaged precipitation** values
- **L** =L1 +L2
  - L1 : global **shift** between QPE and QPF
  - L2 : difference in relative positioning of **objects** in QPE and QPF

**(Wernli et al, 2008)*

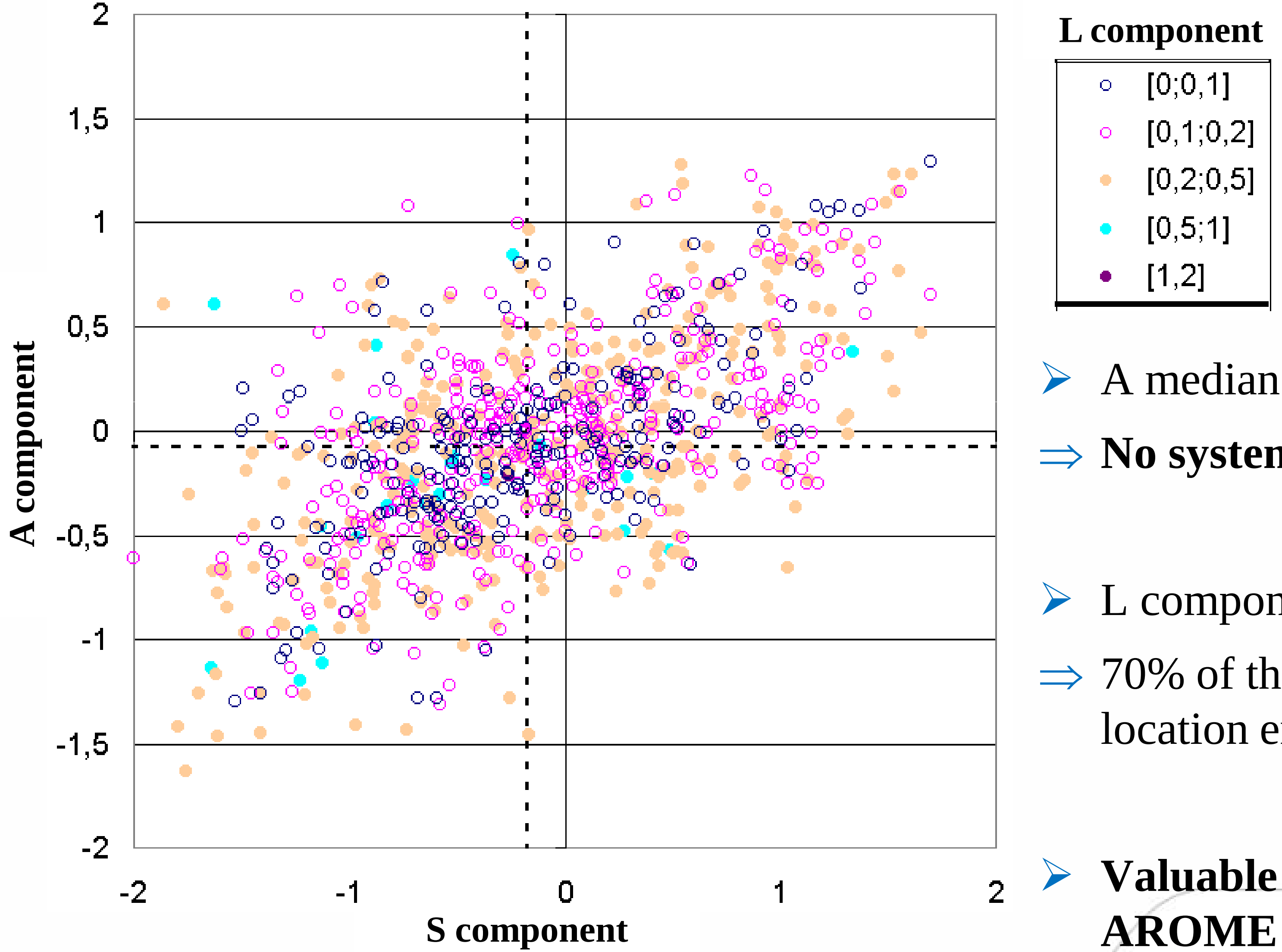
SAL diagram



(Wernli et al, 2008)

Assessment of AROME QPF

- 1-h QPF vs 1-h QPE from Météo-France radar composite
- Days with significant rain from Sept. 2008 to Dec. 2011



SAL diagram for objects with 1-h rain over 2mm

- A median value close to 0

⇒ **No systematic bias**

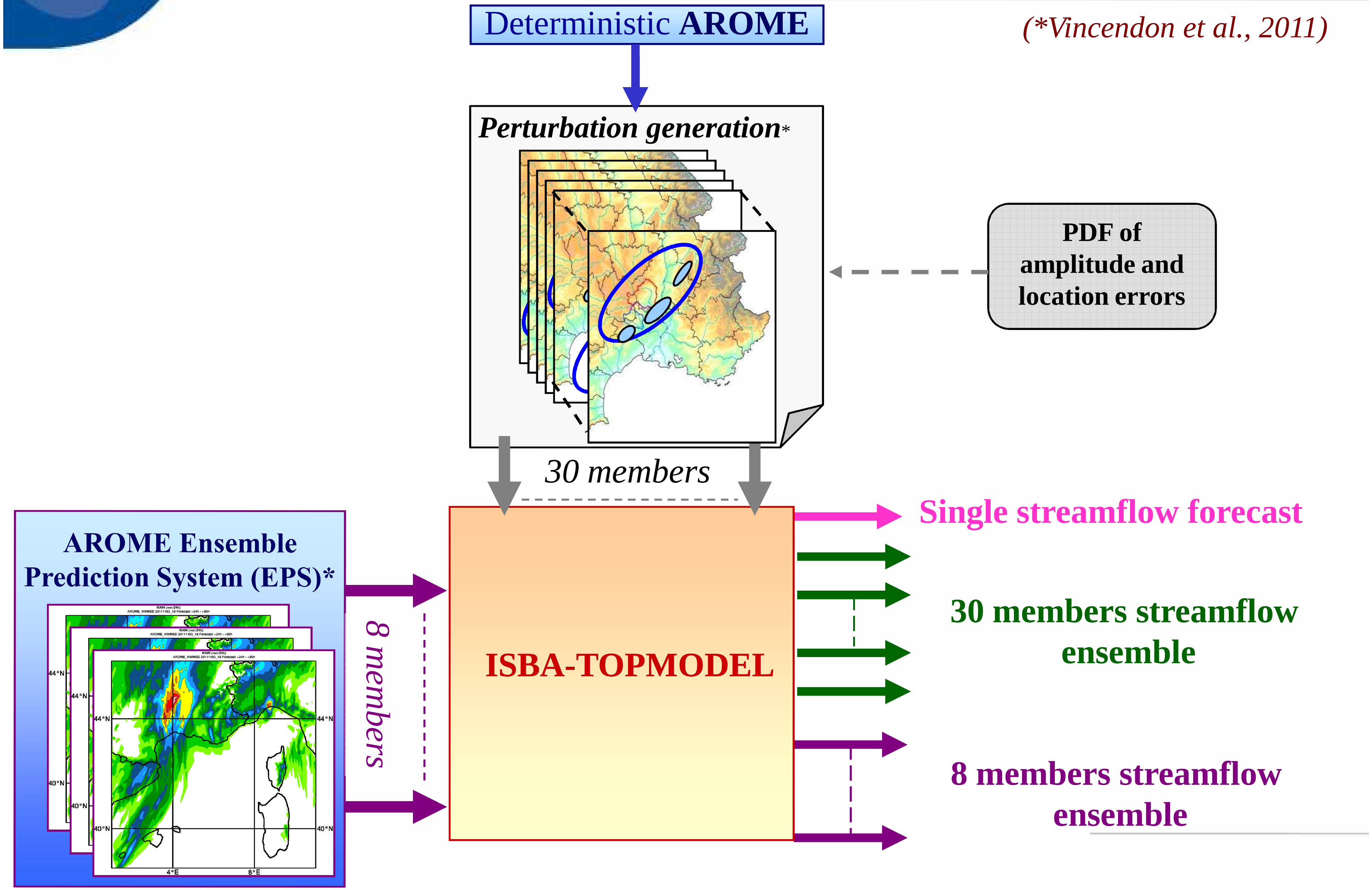
- L component

⇒ 70% of the cases with a location error < 50 km

- **Valuable information in AROME QPF**

Streamflow ensembles with ISBA-TOPMODEL

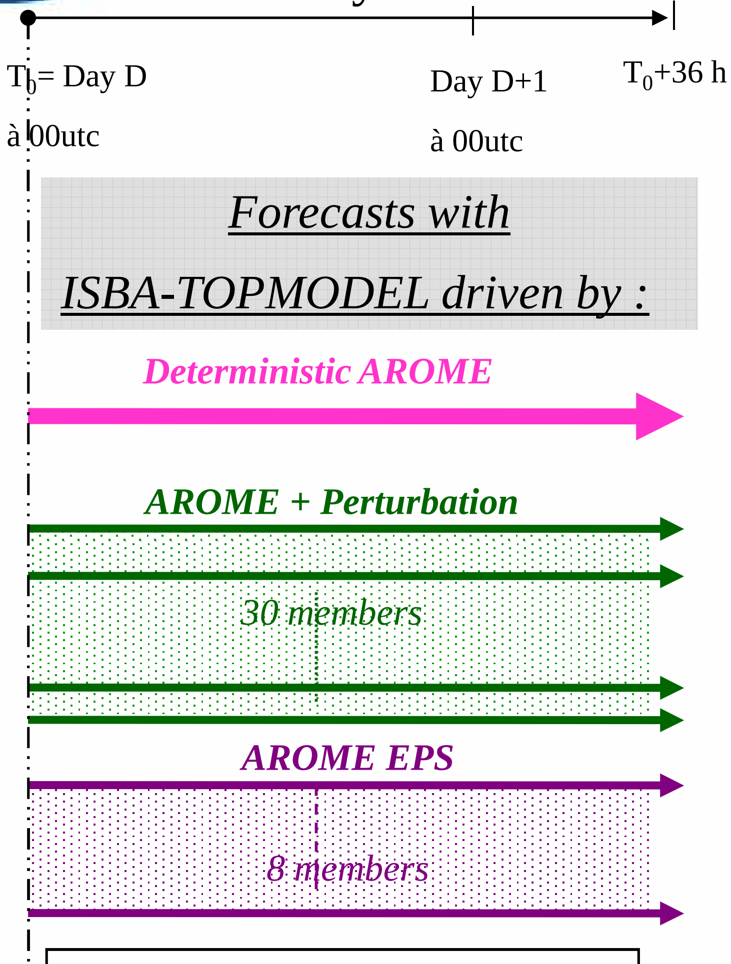
*(*Vincendon et al., 2011)*

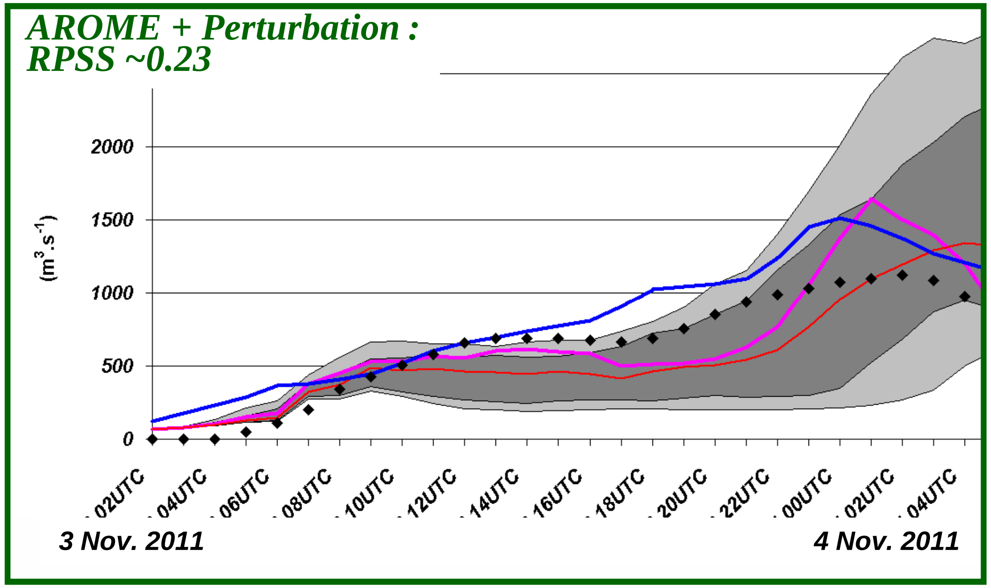


*(*Vié et al., 2011)*

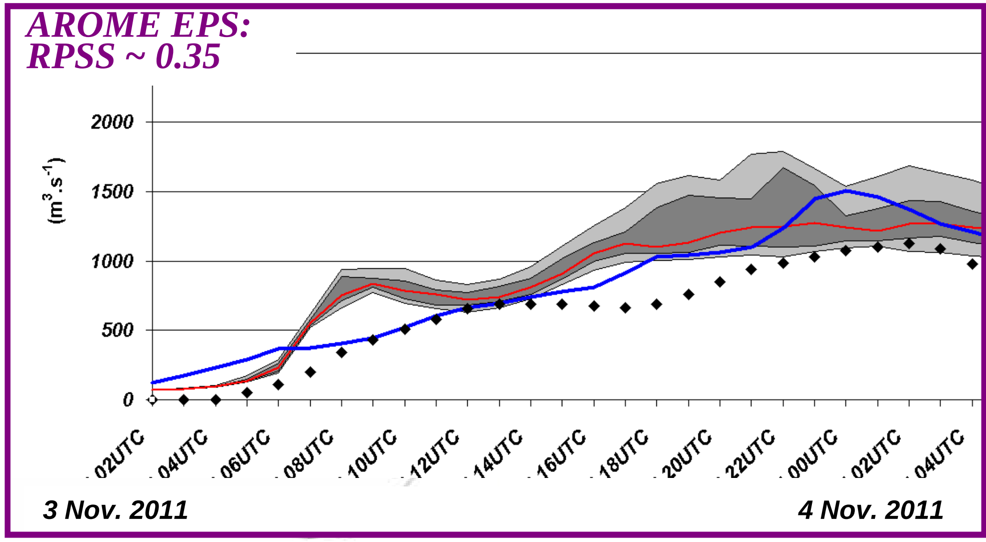
Real time FF forecasting chain within HYMEX SOP

- Daily forecast :





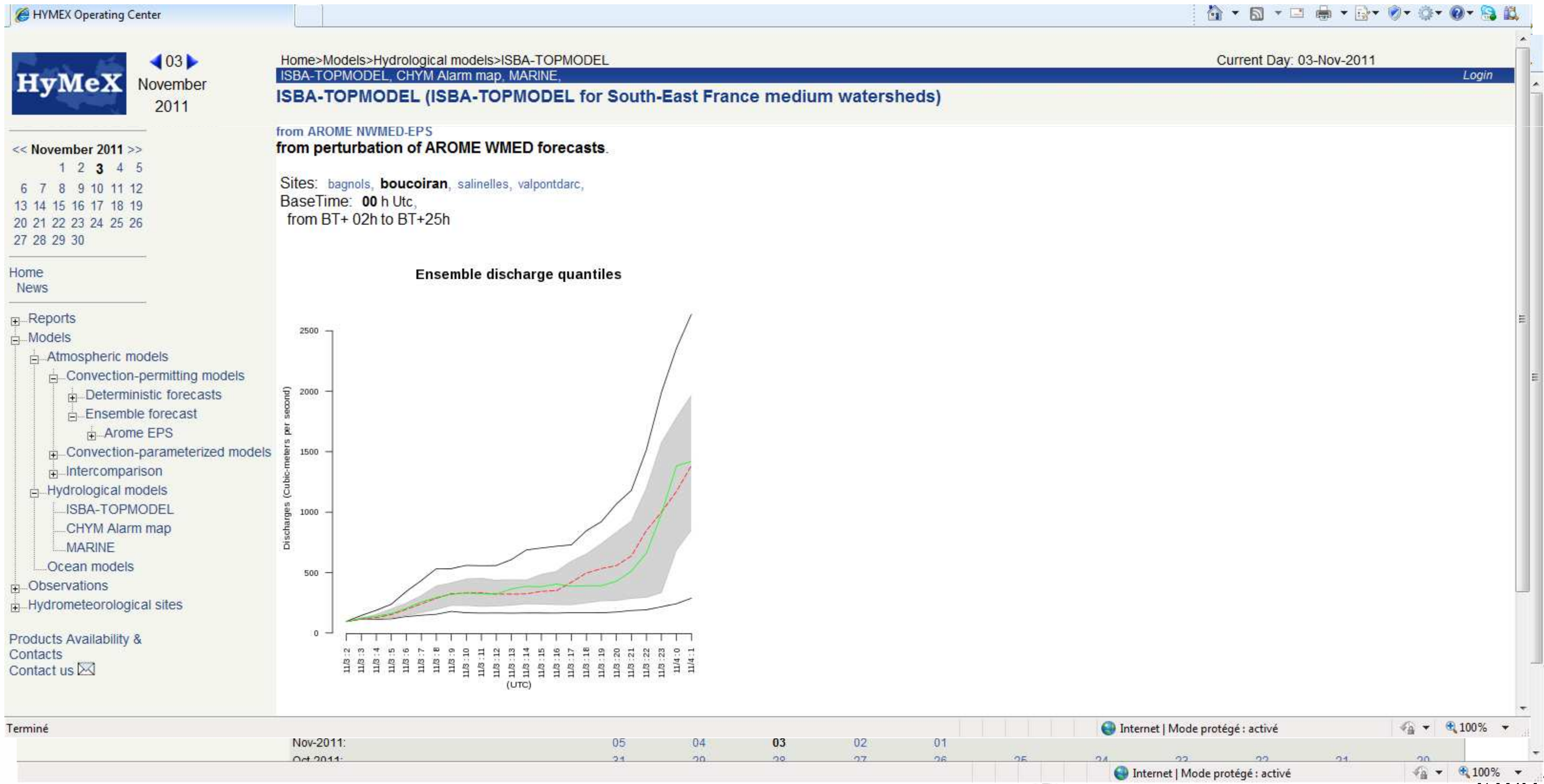
Streamflow ensembles for Gardons river :
3 nov. 2011 @ 02UTC - 4 nov. 2011 @ 04UTC



- *Observation*
- *Simulation driven by radar QPE*
- *Interquartile range of the ensemble*
- *Ensemble median*
- *Forecast with deterministic QPF*

Conclusions and future work

- Usefulness of radar QPE for FF forecasting
  - ⇒ **To document the uncertainty on QPF**
  - ⇒ Method of **perturbation** of QPF to take benefit from valuable information of AROME deterministic forecast
  - ⇒ Streamflow ensemble at reduced numerical cost
- Implemented in real-time for HYMEX SOP : http://sop.hymex.org



Thank you

Bouilloud et al, 2010 :
Bouilloud L., K. Chancibault, B. Vincendon, V. Ducrocq, F. Habets, G.M. Saulnier, S. Anquetin, E. Martin, J. Noilhan , 2009: An advanced coupling between the ISBA land surface model and the TOPMODEL hydrological model to simulate Mediterranean flash-floods, **J. Hydrometeor.**, 11(2),315-333

Vié et al, 2011 :
Vié, B., Nuissier, O., Ducrocq, V., 2010: Cloud-resolving ensemble simulations of heavy precipitating events : uncertainty on initial conditions and lateral boundary conditions, **Mon. Weath. Rev**.,139,403-423

Vincendon et al, 2010 :
Vincendon B., Ducrocq V., Saulnier G.M.; Bouilloud L., Chancibault K., Habets F., Noilhan J. , 2010: Advantages of coupling the ISBA land surface model with a TOPMODEL hydrological model dedicated to Mediterranean flash floods, **J. Hydrology,** 394(1-2), 256-266

Vincendon et al, 2011 :
Vincendon B., Ducrocq V., Nuissier O. et Vié B. , 2011:Introducing perturbation in rainfall fields for an ensemble forecasting of flash-flood, **NHESS,** 11, 1529-1544

Wernli et al, 2008 :
Wernli H., Paulat M., Heigen M. and Frei C., 2008 : SAL A novel quality measure for the verification of quantitative precipitation forecast , **Mon. Weath. Rev**., 136,4470-4487

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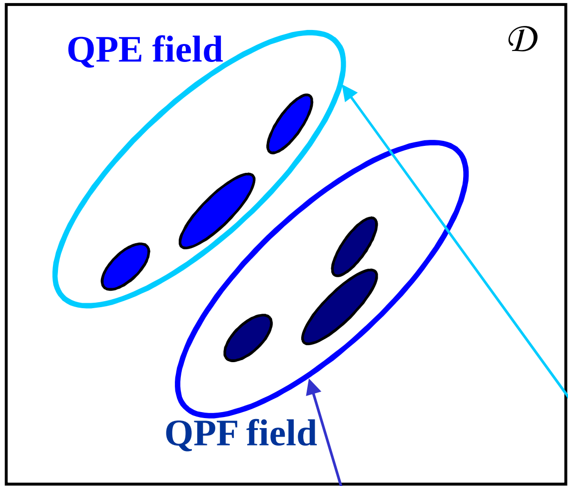
Point-to-point assessment of QPF values

- **A** : characterizes how different are domain-averaged precipitation values



Observed $\mathcal{D}$-averaged precipitation

$$A = 2.\frac{\overline{R_{mod}} - \overline{R_{obs}}}{\overline{R_{mod}} + \overline{R_{obs}}}$$

Modelled $\mathcal{D}$-averaged precipitation

**(Wernli et al, 2008)*

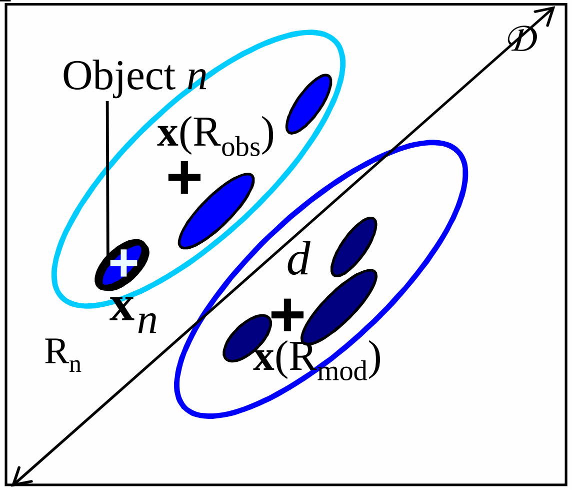
Point-to-point assessment of QPF values

- L =L1 +L2
- L1 characterizes the global shift between QPE and QPF

Barycentre of the QPE field among $\mathcal{D}$

$$L1 = \frac{|\mathbf{x}(R_{mod}) - \mathbf{x}(R_{obs})|}{d}$$

Maximal distance among $\mathcal{D}$



- L2 characterizes the spatial precipitation distribution inside the domain.

Total number of objects

Barycentre of object n

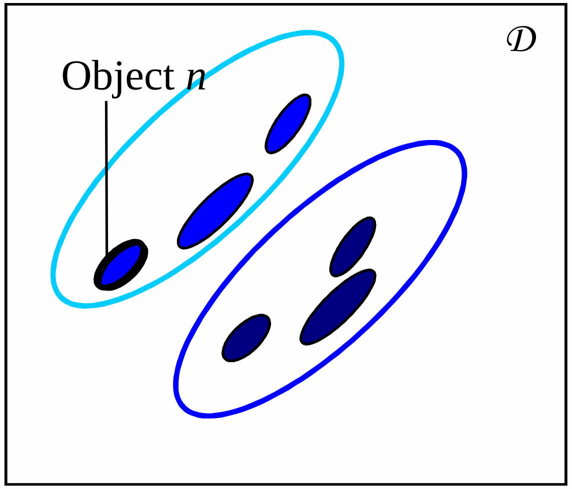
$$L2 = 2\frac{|r_{mod} - r_{obs}|}{d} \qquad r = \frac{\sum_{n=1}^{M} R_n |\mathbf{x} - \mathbf{x}_n|}{\sum_{n=1}^{M} R_n}$$

Mean rainfall on object n

(Wernli et al, 2008)

Point-to-point assessment of QPF values

- S: characterizes the size of the rainy objects as well as the gradient



$$V = \frac{\sum_{n=1}^{M} R_n . V_n}{\sum_{n=1}^{M} R_n}$$

$$V_n = \frac{R_n}{R_n^{max}}$$

Maximal rainfall on object n

$$S = 2.\frac{V_{mod} - V_{obs}}{V_{mod} + V_{obs}}$$

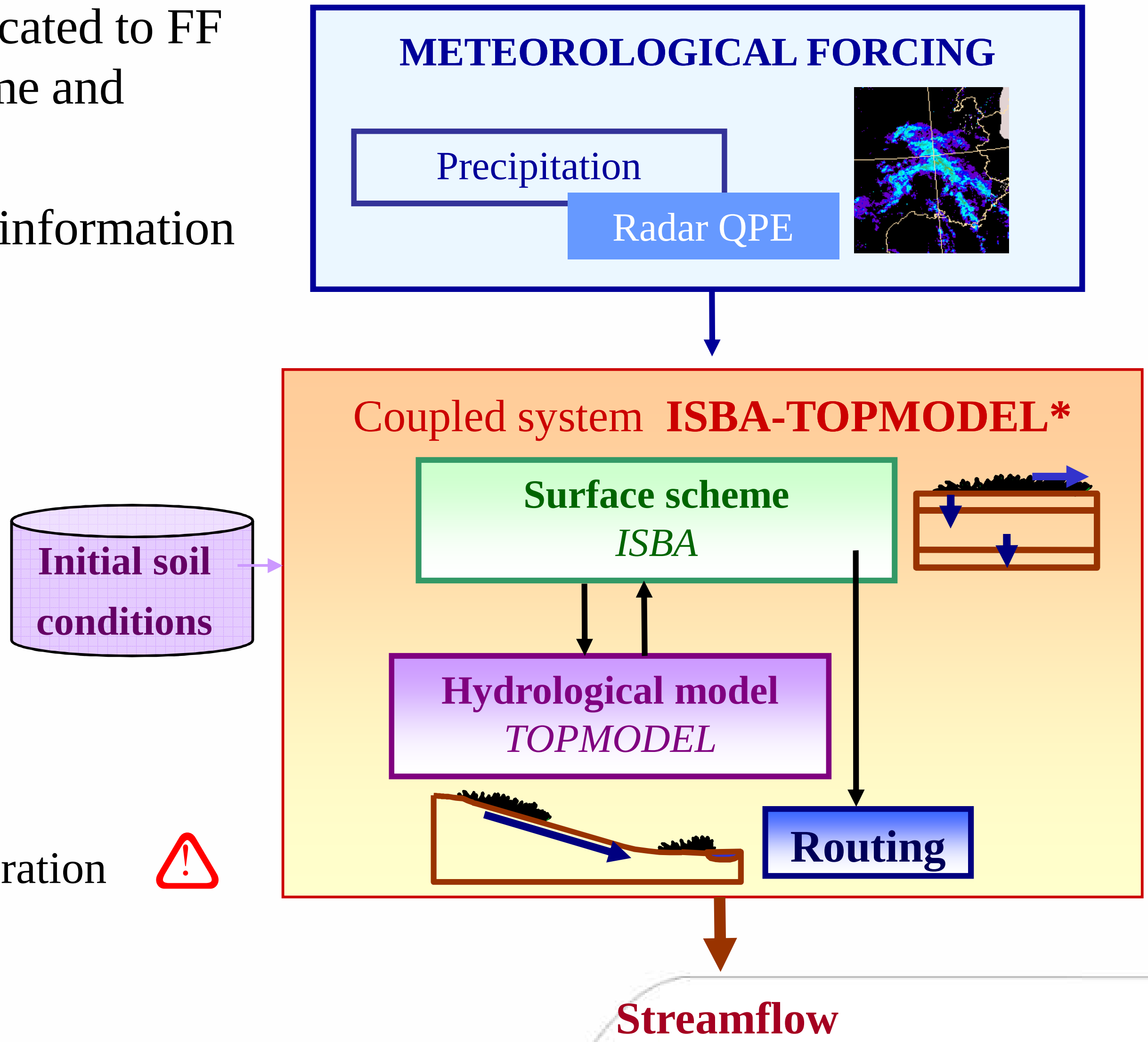
(Wernli et al, 2008)

Usefullness of radar QPE for FF forecasting?

➢ FF simulation:

➢ Hydrological models dedicated to FF sensitive to rainfall (volume and spatial distribution)

⇒ Radar QPE = appropriate information



➢ Use of radar QPE for :

- ➢ hydrological simulation
- ➢ hydrological models calibration ⚠

*Bouilloud et al, 2010; Vincendon et al, 2010

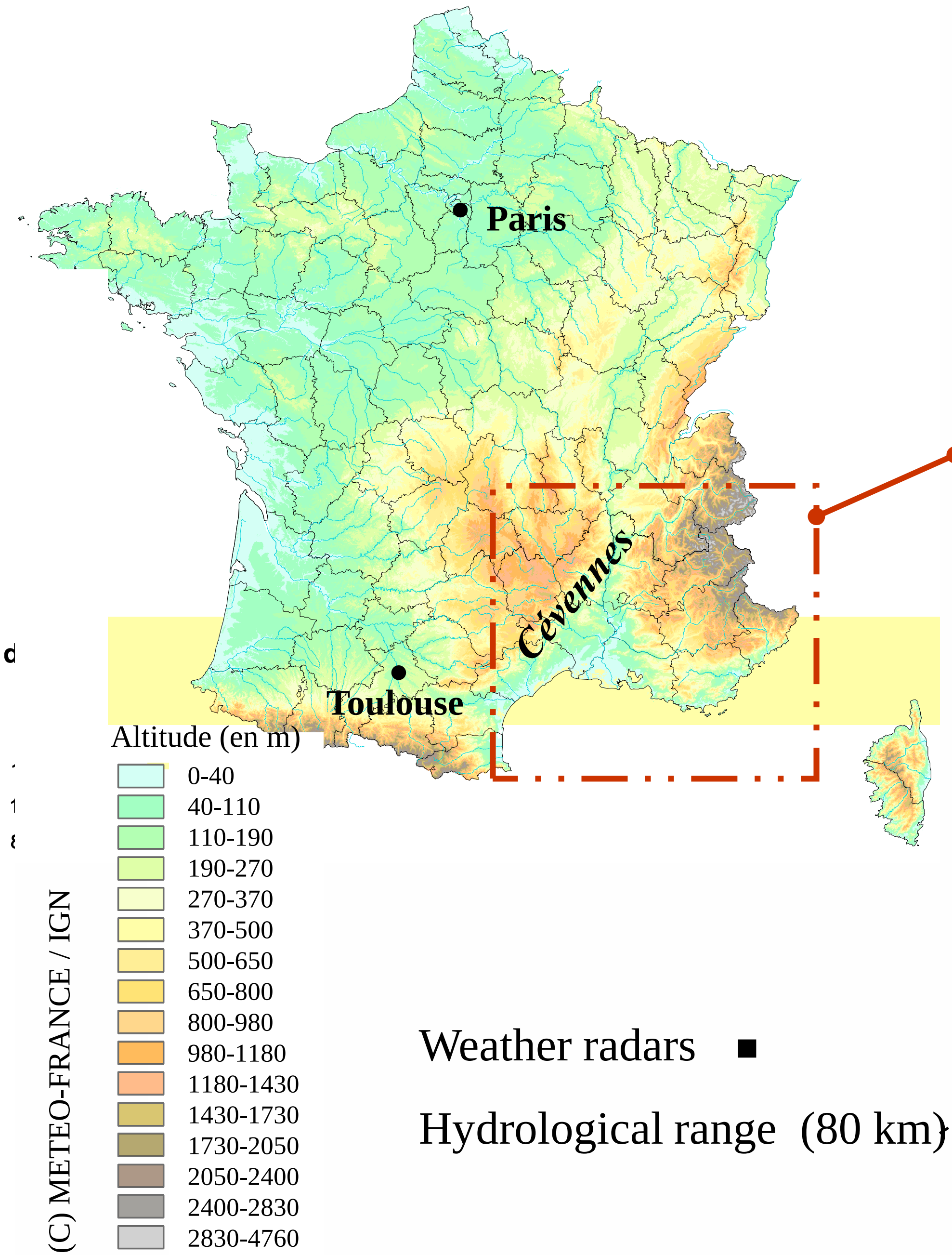
Uncertainty on FF simulations due to QPE

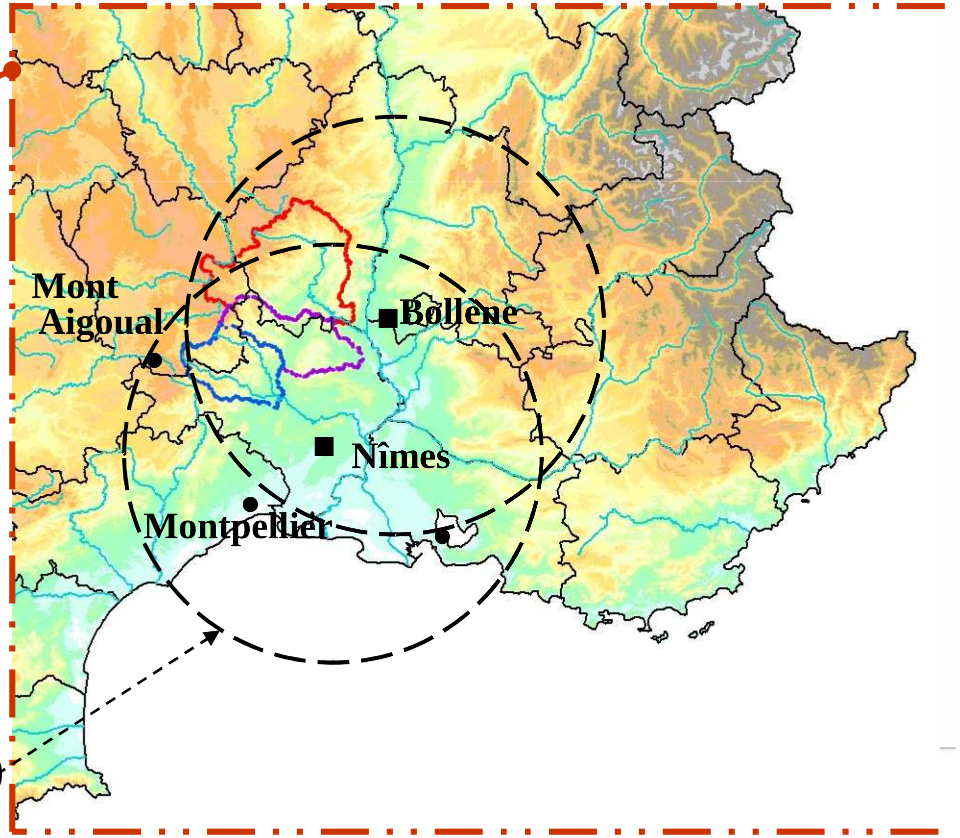
Rivers:

Ardèche at Saint Martin (2240 km²)

Cèze at Bagnols-sur-Cèze (1100 km²)

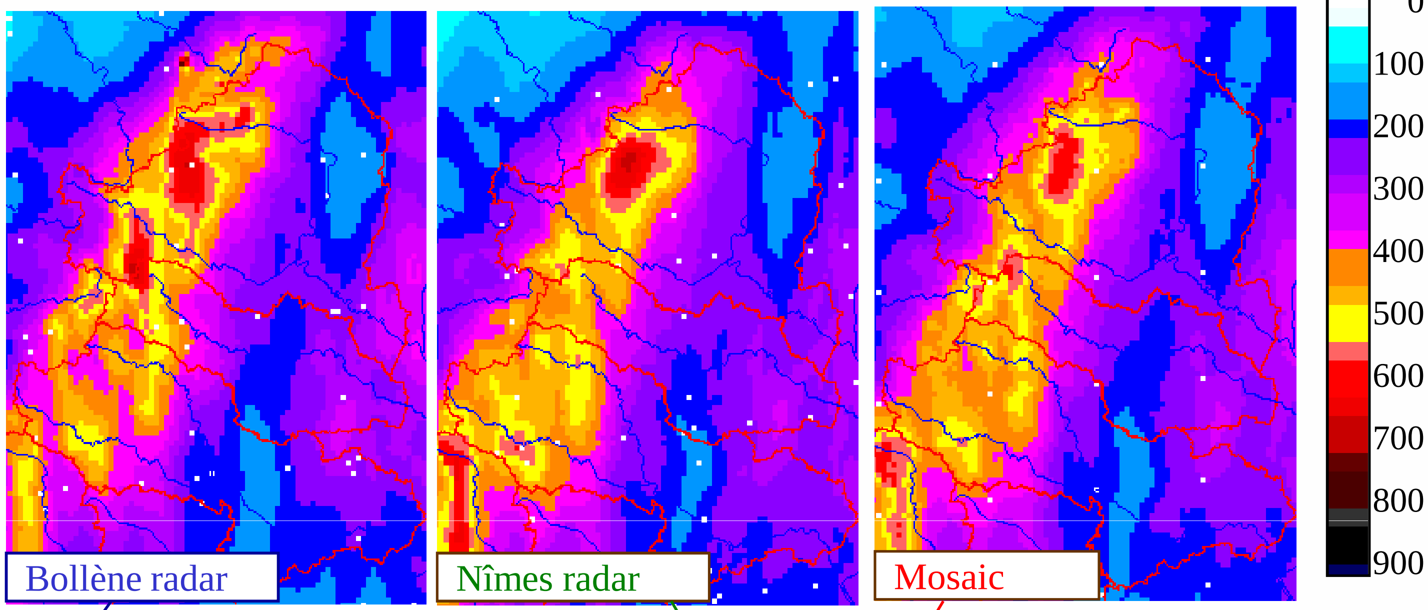
Gardons at Ners (1090km²)

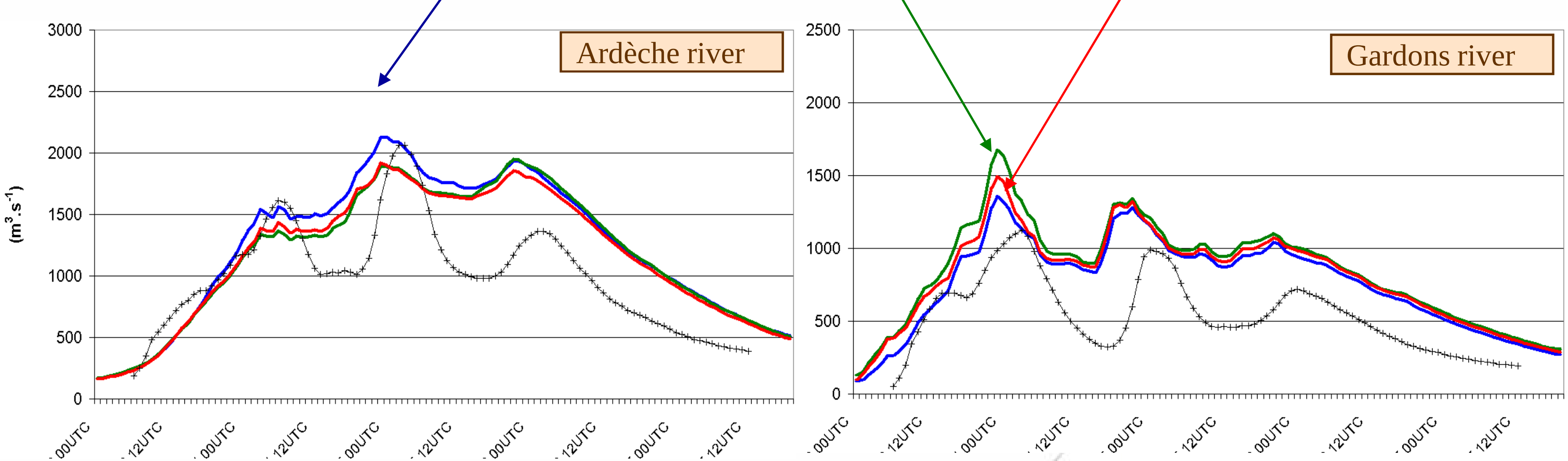




Uncertainty on FF simulations due to QPE: November 2011 case

QPEs (mm) from 3rd nov. 2011 at 12UTC to 8 nov. 2011 at 00UTC

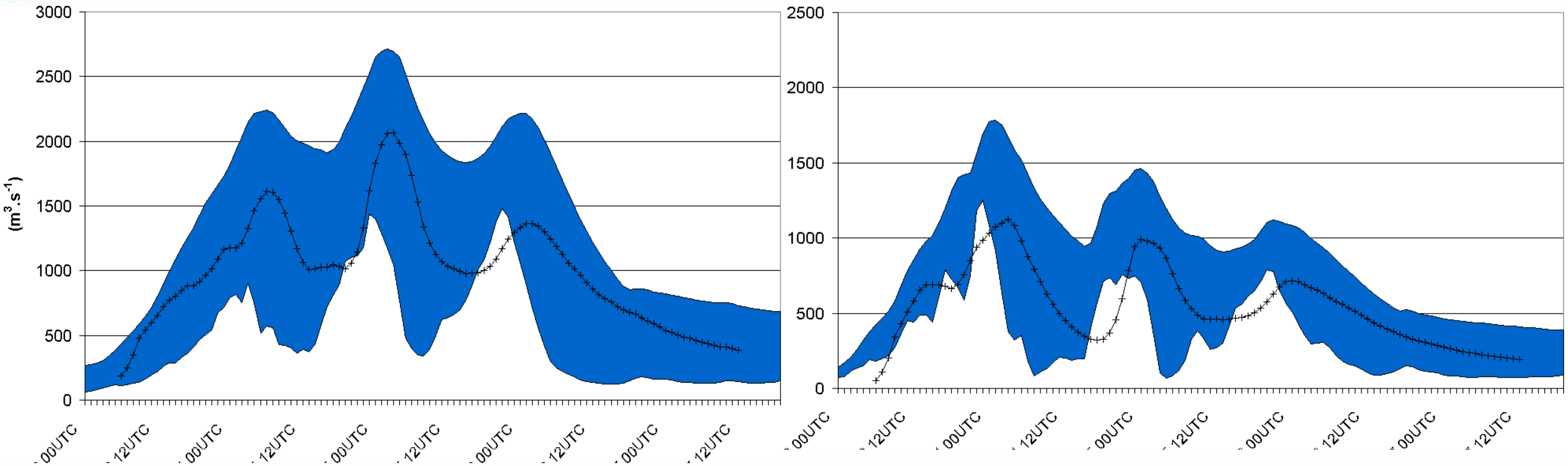




Discharges ($m^3.s^{-1}$) from 3rd nov. 2011 at 12UTC to 8 nov. 2011 at 00UTC

Uncertainty on FF simulations due to QPE: November 2011 case

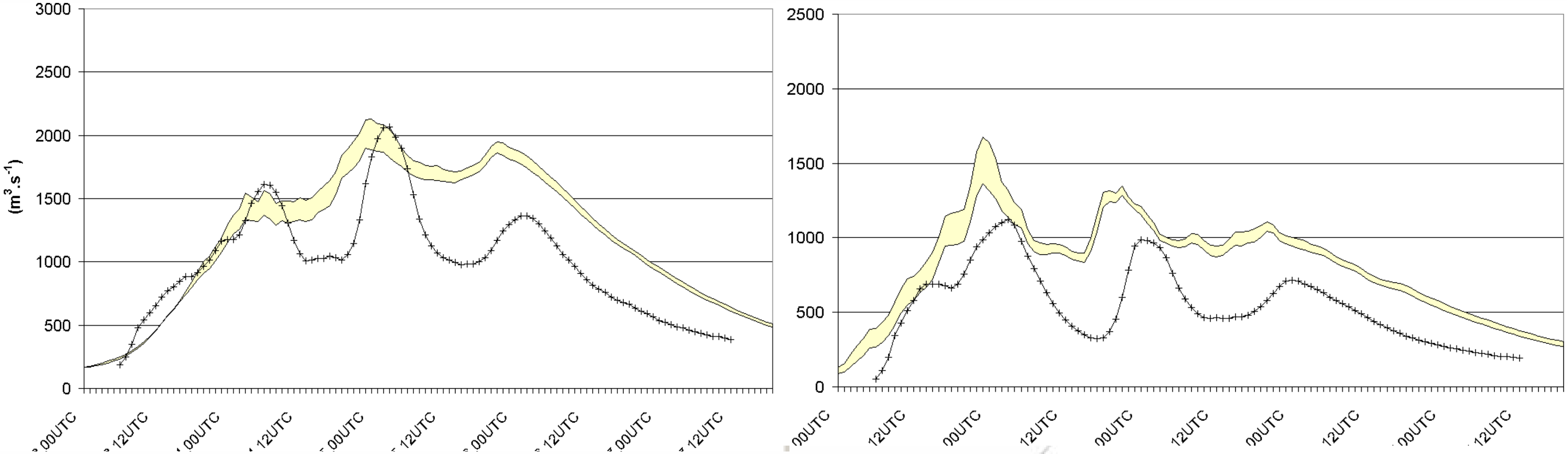
Several parameters



Ardèche river

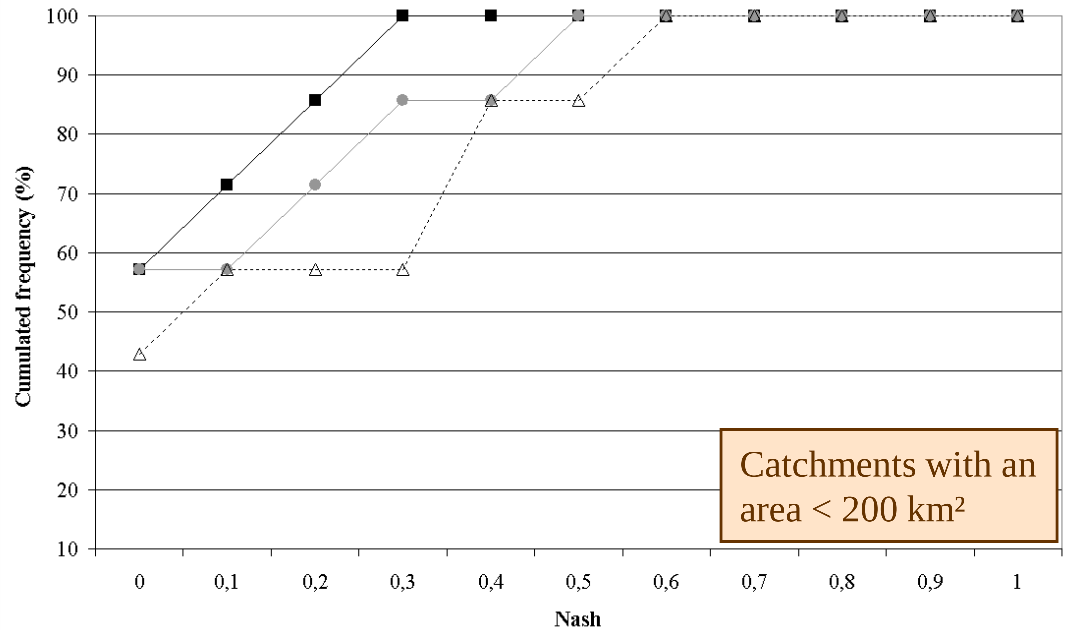
Gardons river

Several radar data



Discharges (m^3.s^{-1}) from 3rd nov. 2011 at 12UTC to 8 nov. 2011 at 00UTC

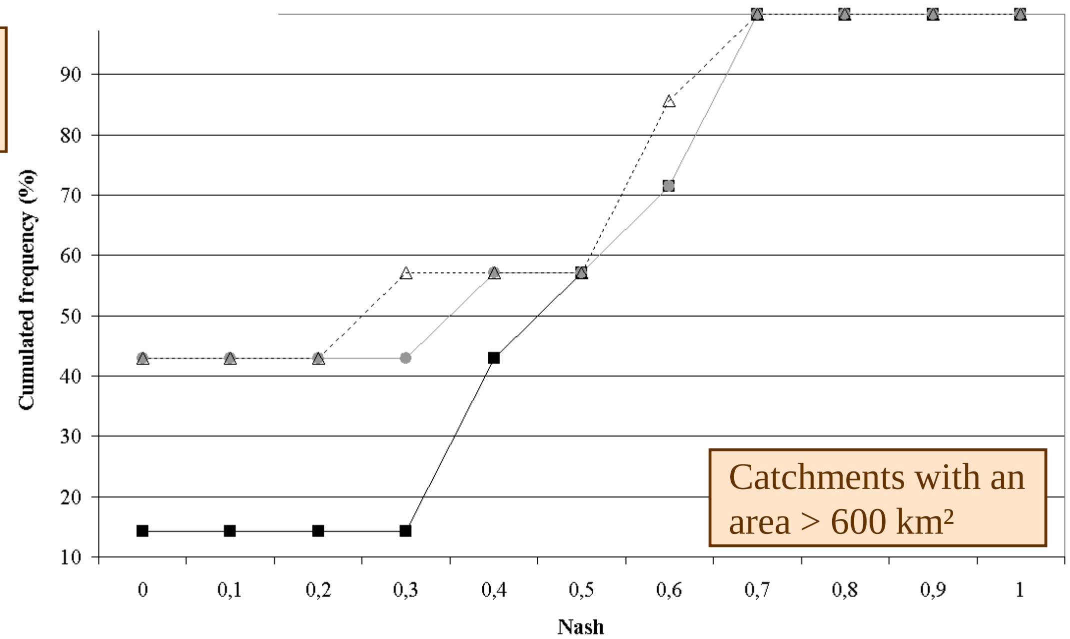
Sensitivity to radar QPE time step



Temporal frequency:

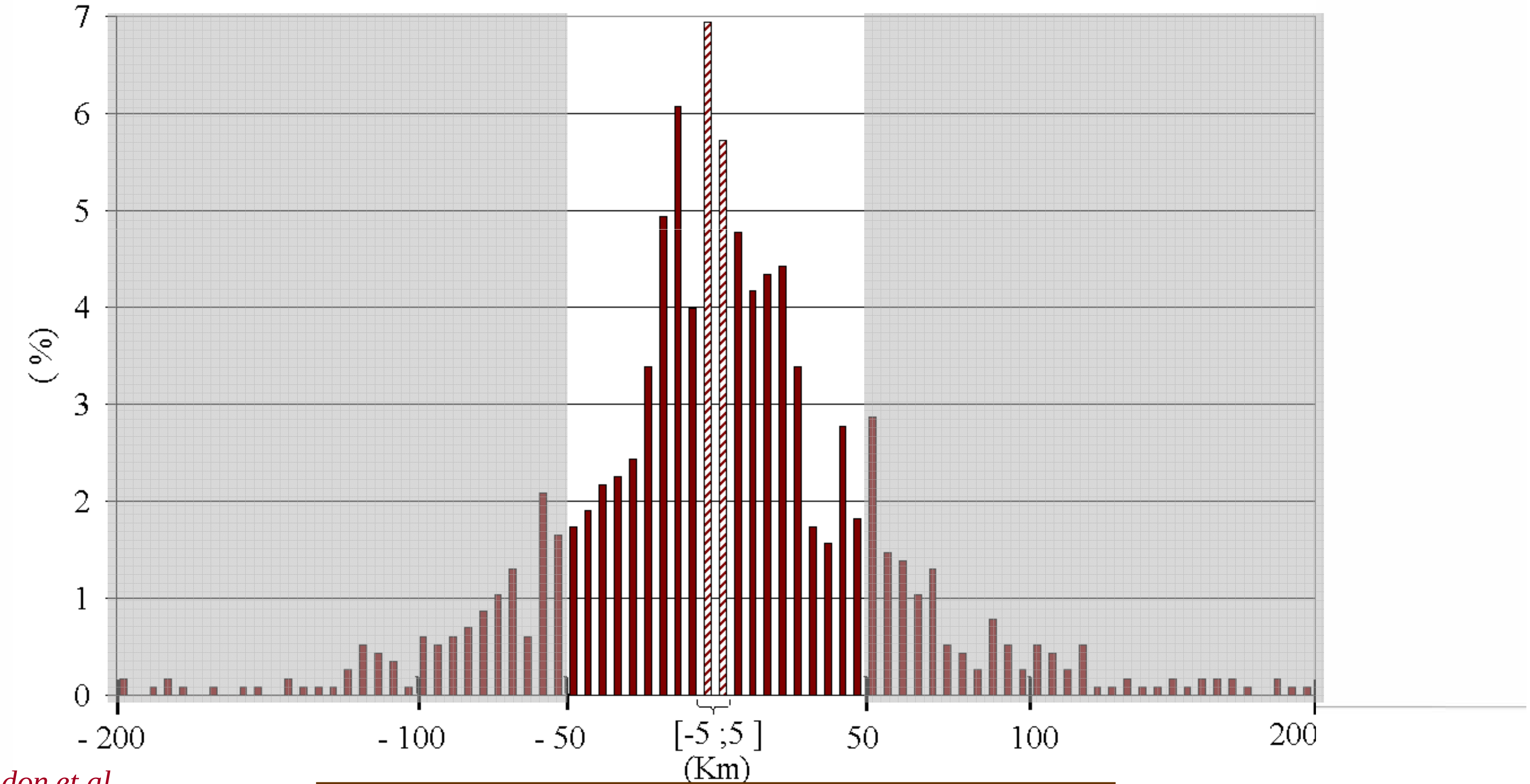
- 1h
- 15 minutes
- 05 minutes

Cumulated frequencies of nash efficiency (Prediflood project)



Quantification of AROME QPF error

- PDF of amplitude and location errors for object ***Or*** and ***Oc***
- Amplitude errors : no systematic bias
- Location errors : < 50 km in 70% of cases

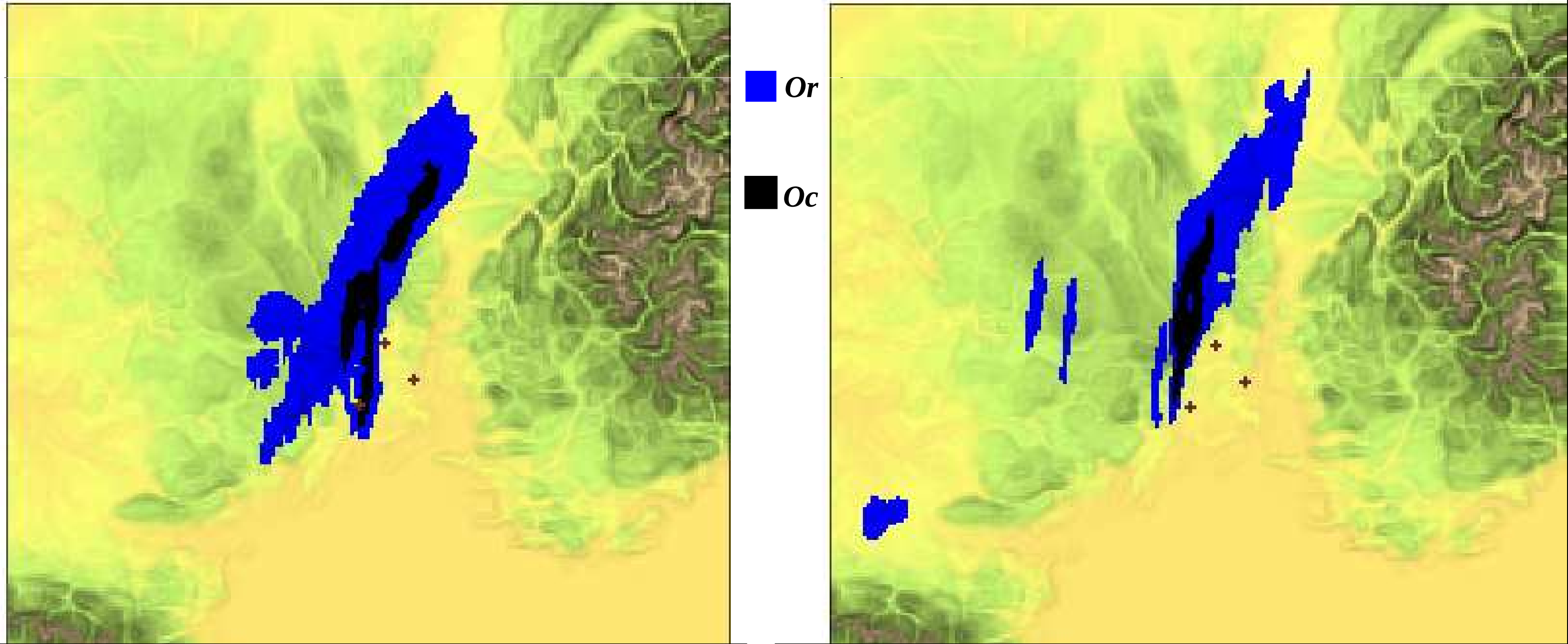


PDF of location errors for ***Or*** objects along E/W axe

(Vincendon et al., NHESS, in revision)

Quantification of AROME QPF error

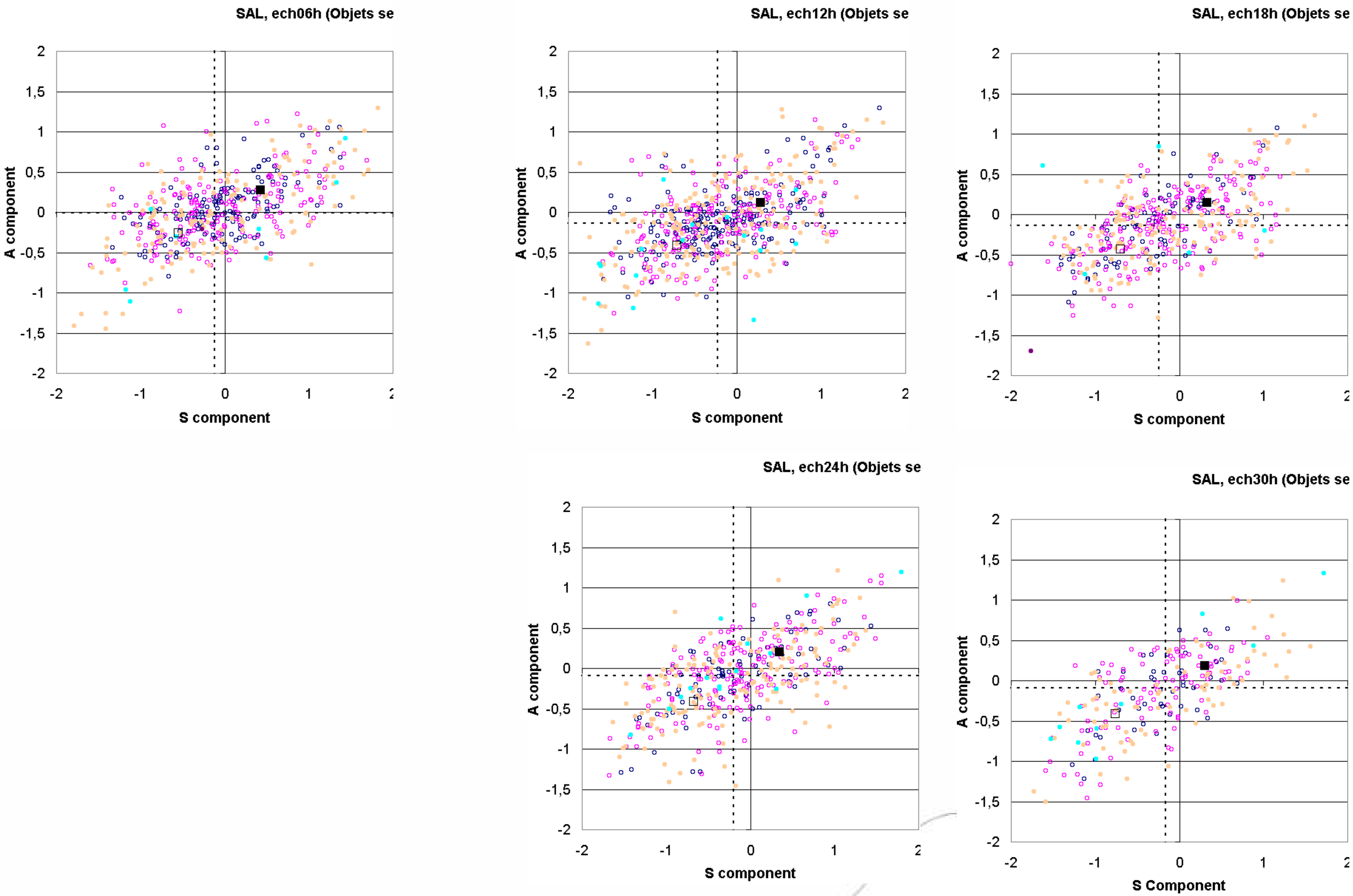
- AROME hourly QPF *vs* Météo-France radar hourly QPE
- Significant rainy events
- Object–based climatology of AROME QPF errors :
  - Rainy objects = ***Or***
  - Convective objects = ***Oc***



1h-radar QPE the 01 Nov. 2008 at 20UTC

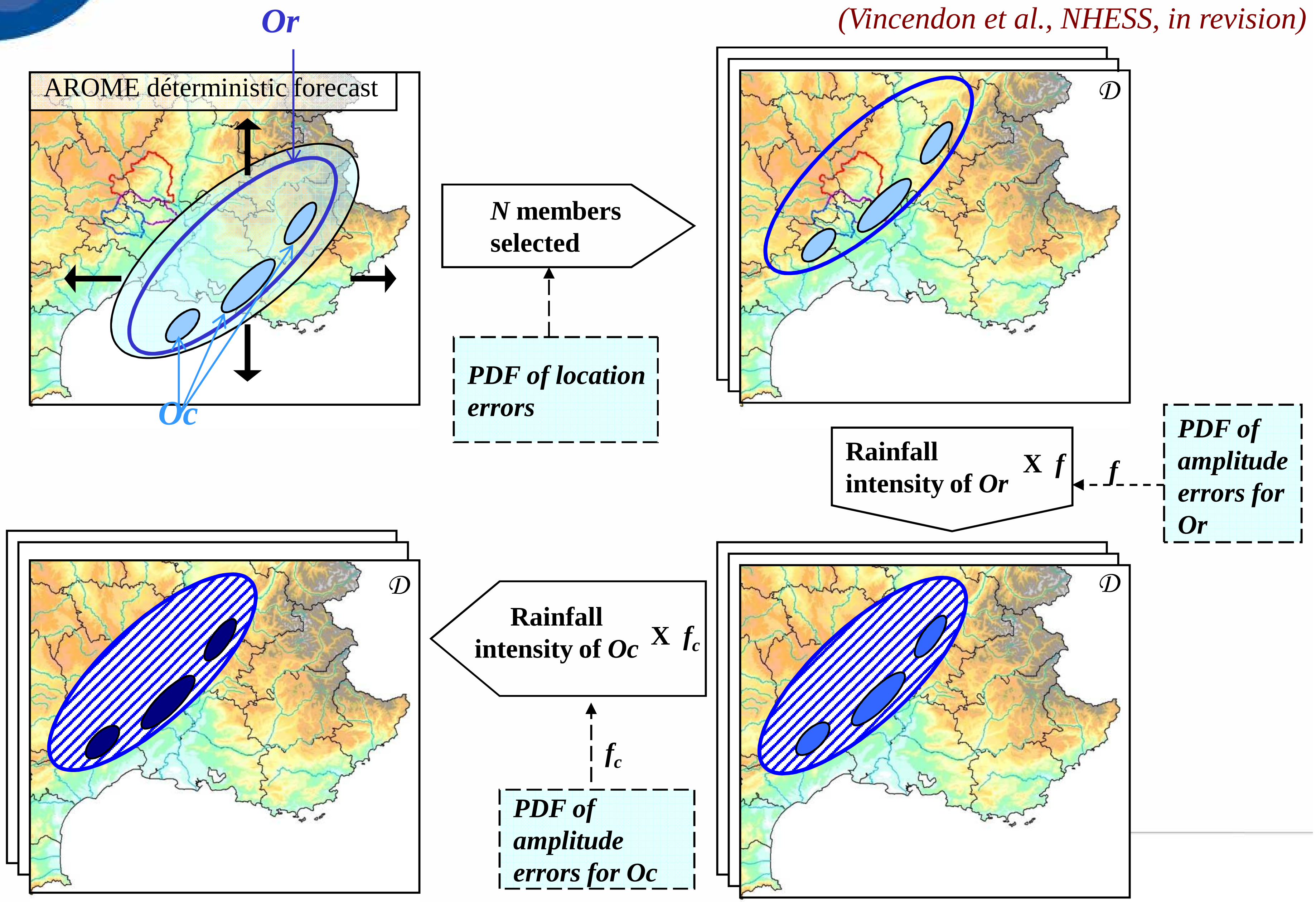
1h-AROME QPF the 01 Nov. 2008 at 20UTC (AROME run start = 01/11/2008 analyse)

Quantification of AROME QPF error



Perturbation generation method

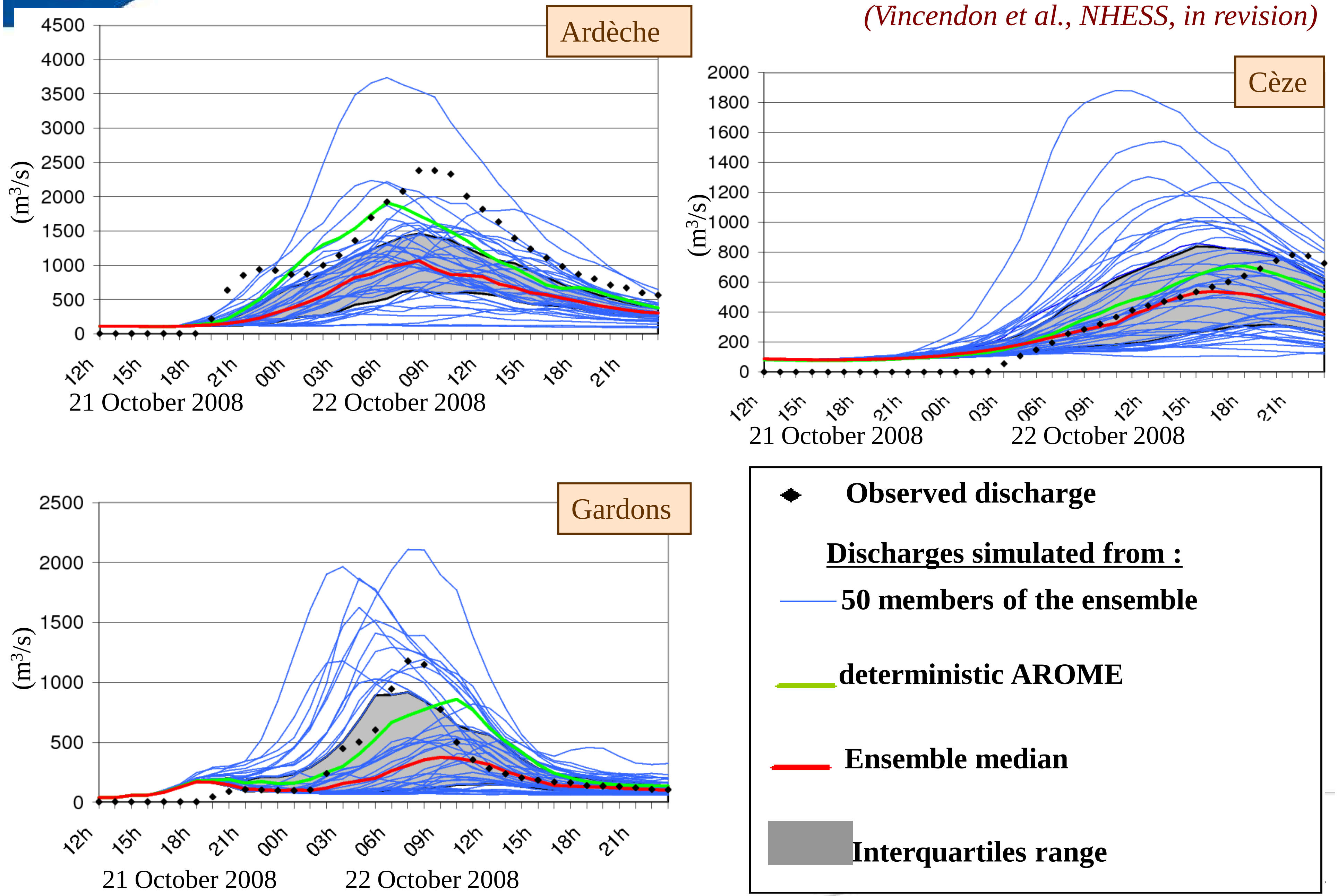
(Vincendon et al., NHESS, in revision)



N new fields

Streamflow ensemble for 21-22 October 2008 event

(Vincendon et al., NHESS, in revision)



Observed discharge

Discharges simulated from :

50 members of the ensemble

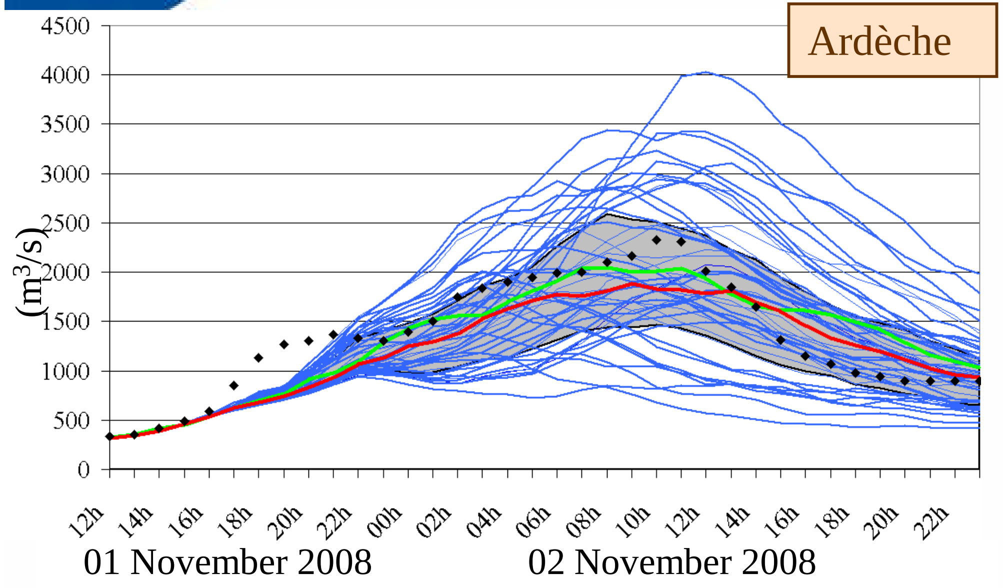
deterministic AROME

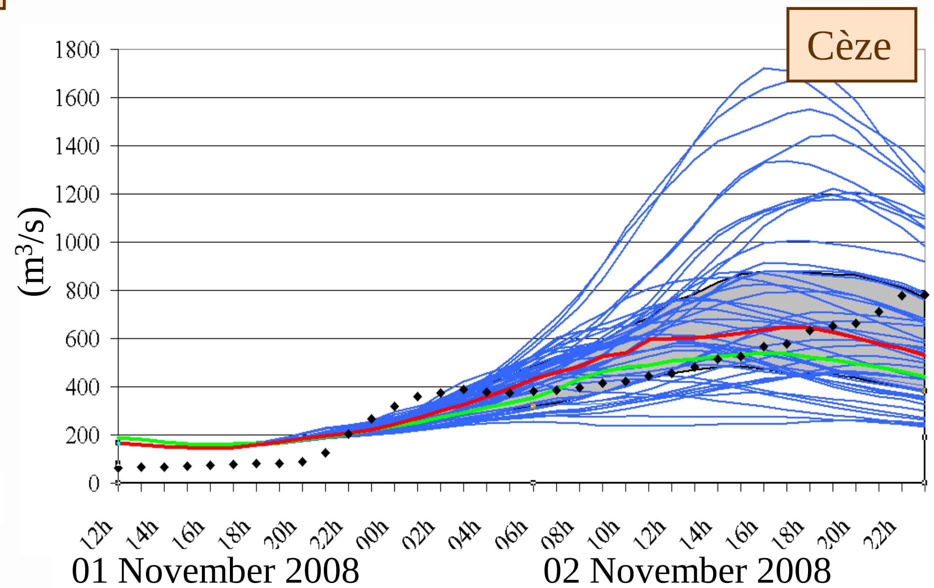
Ensemble median

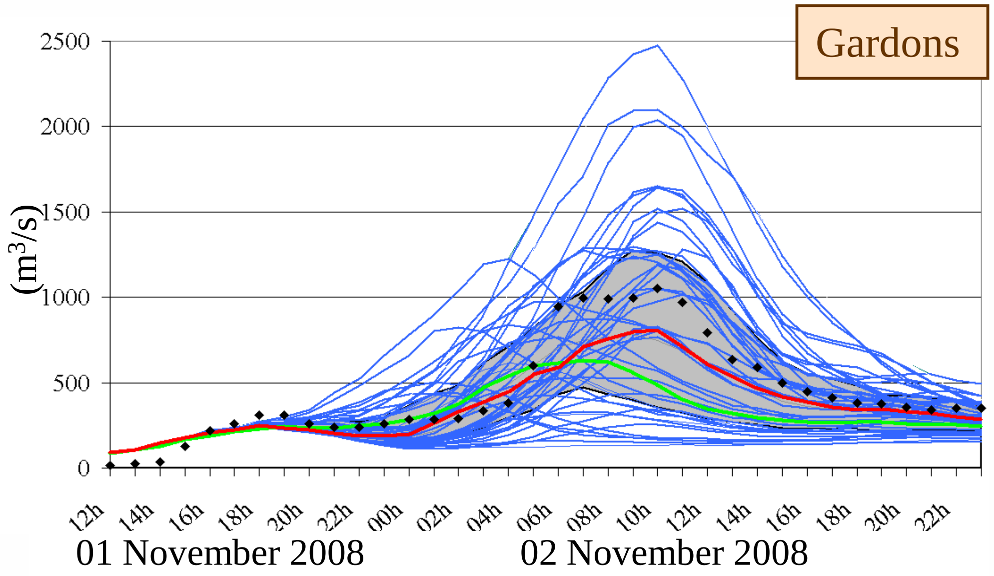
Interquartiles range

Streamflow ensemble for 01-02 November 2008 event

(Vincendon et al., NHESS, in revision)







Observed discharge

<u>Discharges simulated from :</u>

50 members of the ensemble

deterministic AROME

Ensemble median

Interquartiles range

Early verification

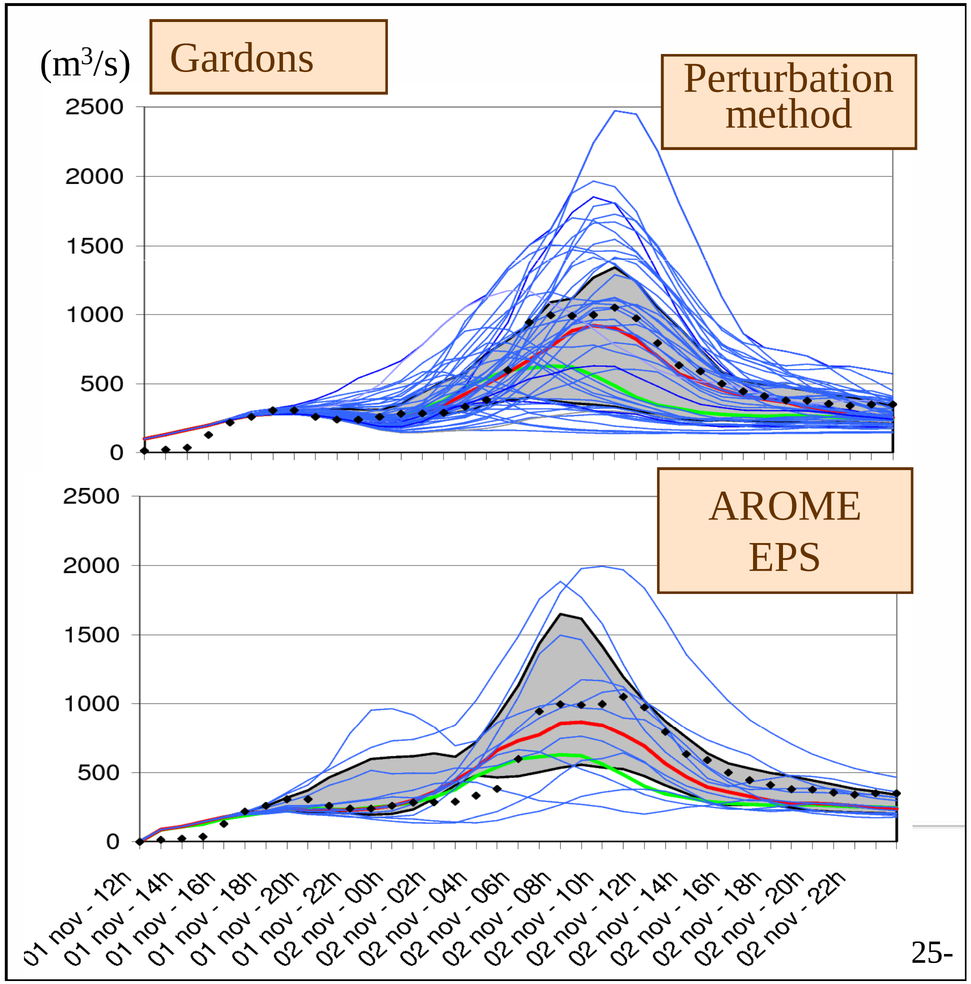
- RPSS ~ 0.35 mm/day on 24h-accumulated rainfall

⇒ **Ensemble forecast > deterministic forecast**

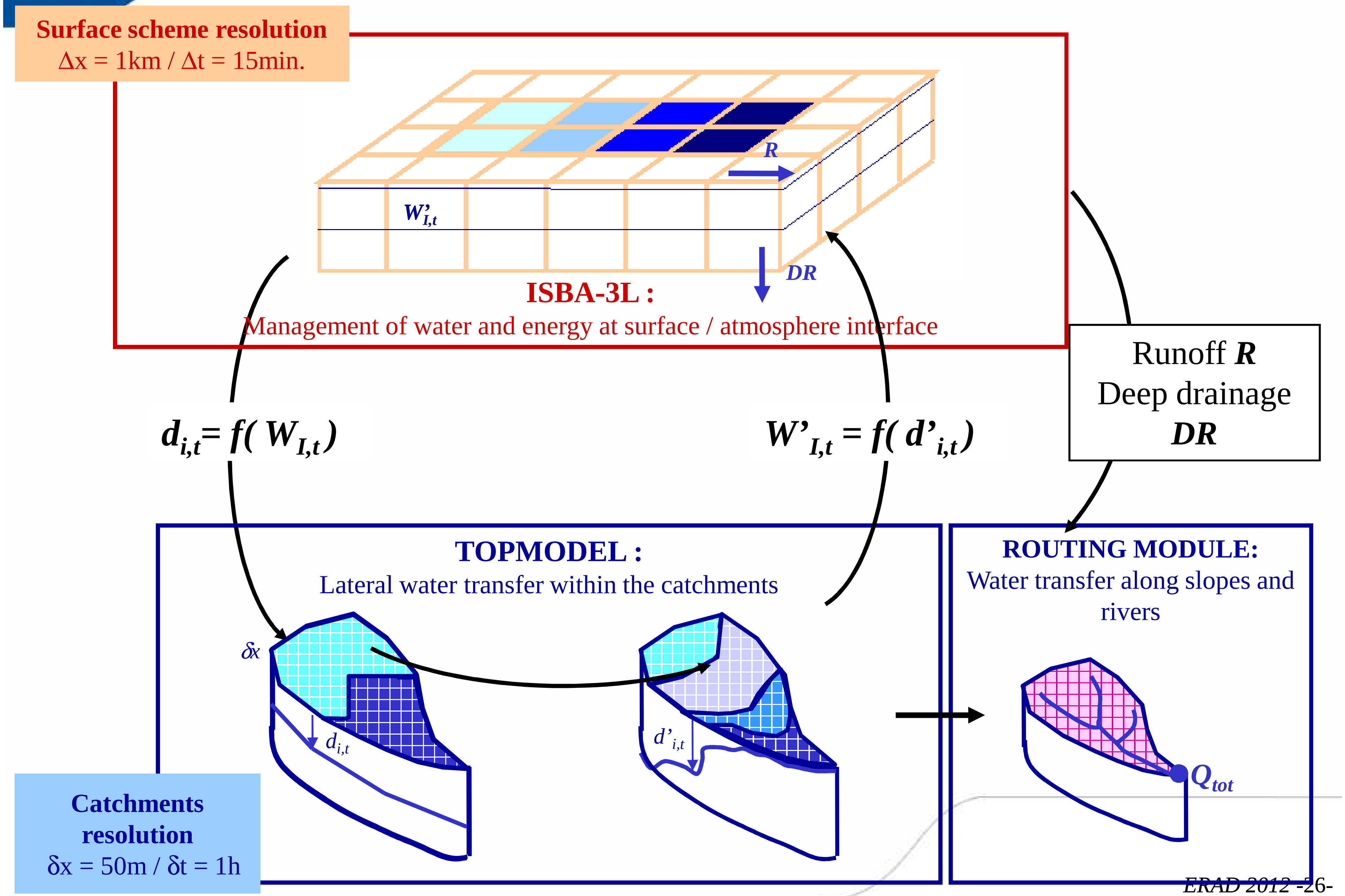
- Comparison to a research AROME EPS *(Vié et al., 2010)*

⇒ **Close results**

- Advantage of the perturbation method:
  - Reduced numerical cost
  - Lot of members

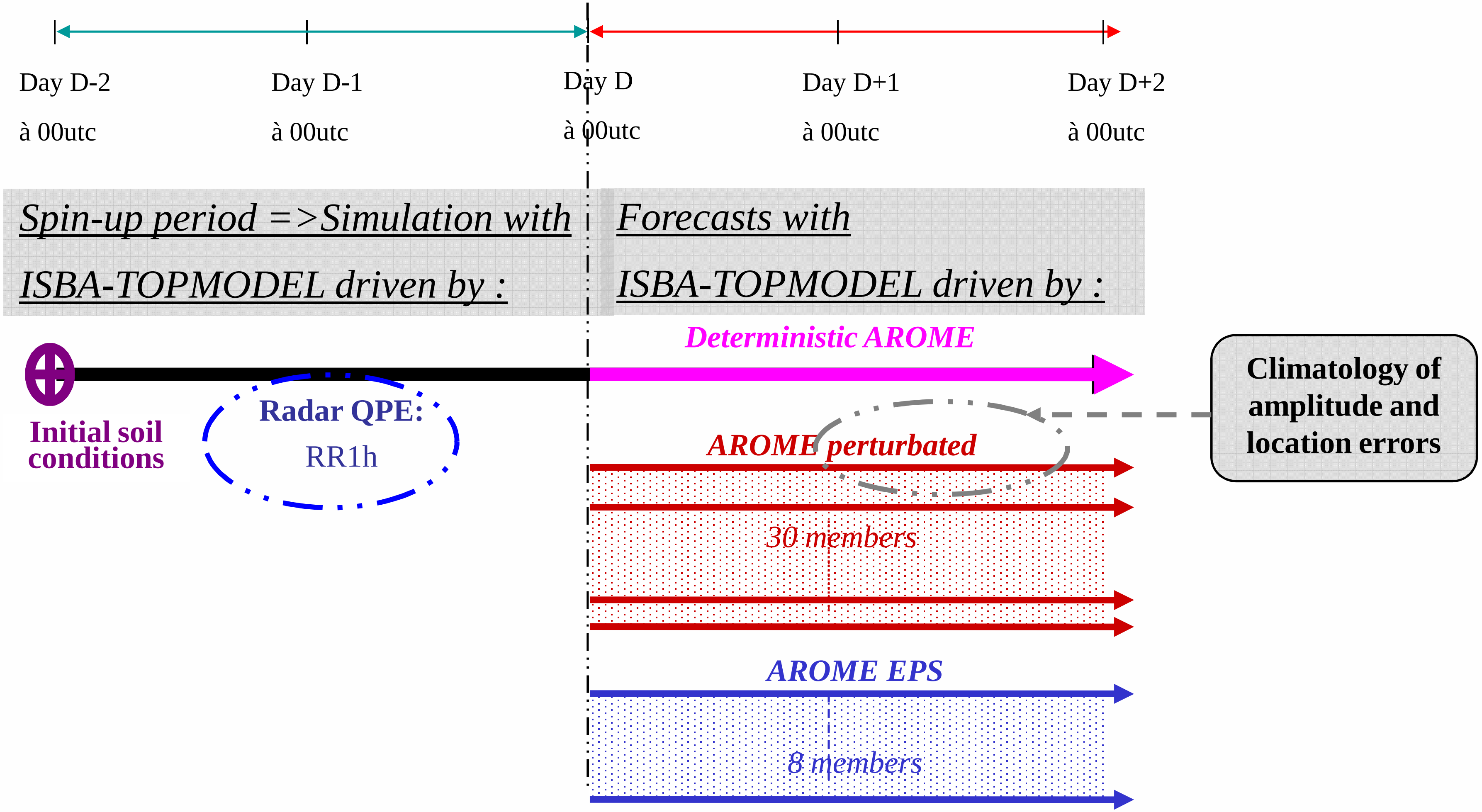


How do we simulate Mediterranean FF?



Real time FF forecasting chain within HYMEX SOP

- Daily forecast :



- Usefullness of radar QPE in this framework?
  - FF simulation
  - QPF assessment