3rd HEPEX Workshop

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HYDROLOGICAL ENSEMBLE PREDICTION SYSTEMS: THE 1966 "CENTURY" FLOOD EXPERIMENT

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Objectives

- verify the capabilities of coupled meteorological and hydrological forecasting systems in forecasting **extreme** floods
- **investigate** the possibility of using the *ensemble* of predicted meteorological fields to drive HEPS-**Hydrological Ensemble Prediction Systems**
- **assess uncertainties in flood prediction** (the flood peaks, volumes, etc.) induced by uncertainties of rainfall forecasts
- **identify suitable strategies** to select representative members of GCM *ensembles* to be downscaled in real-time by MMM-Mesoscale Meteorological Models and a hydrological flood model

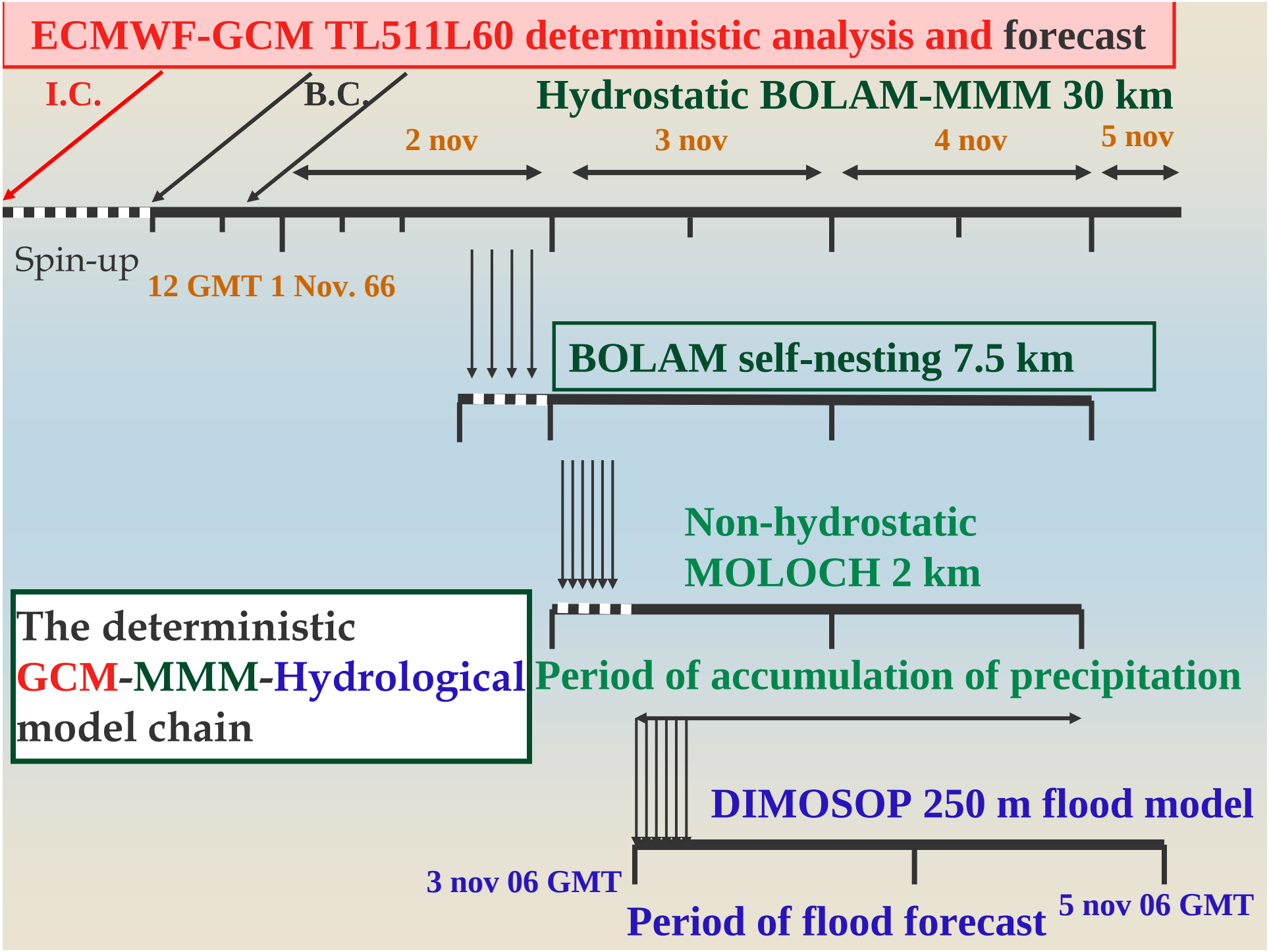
Methodology

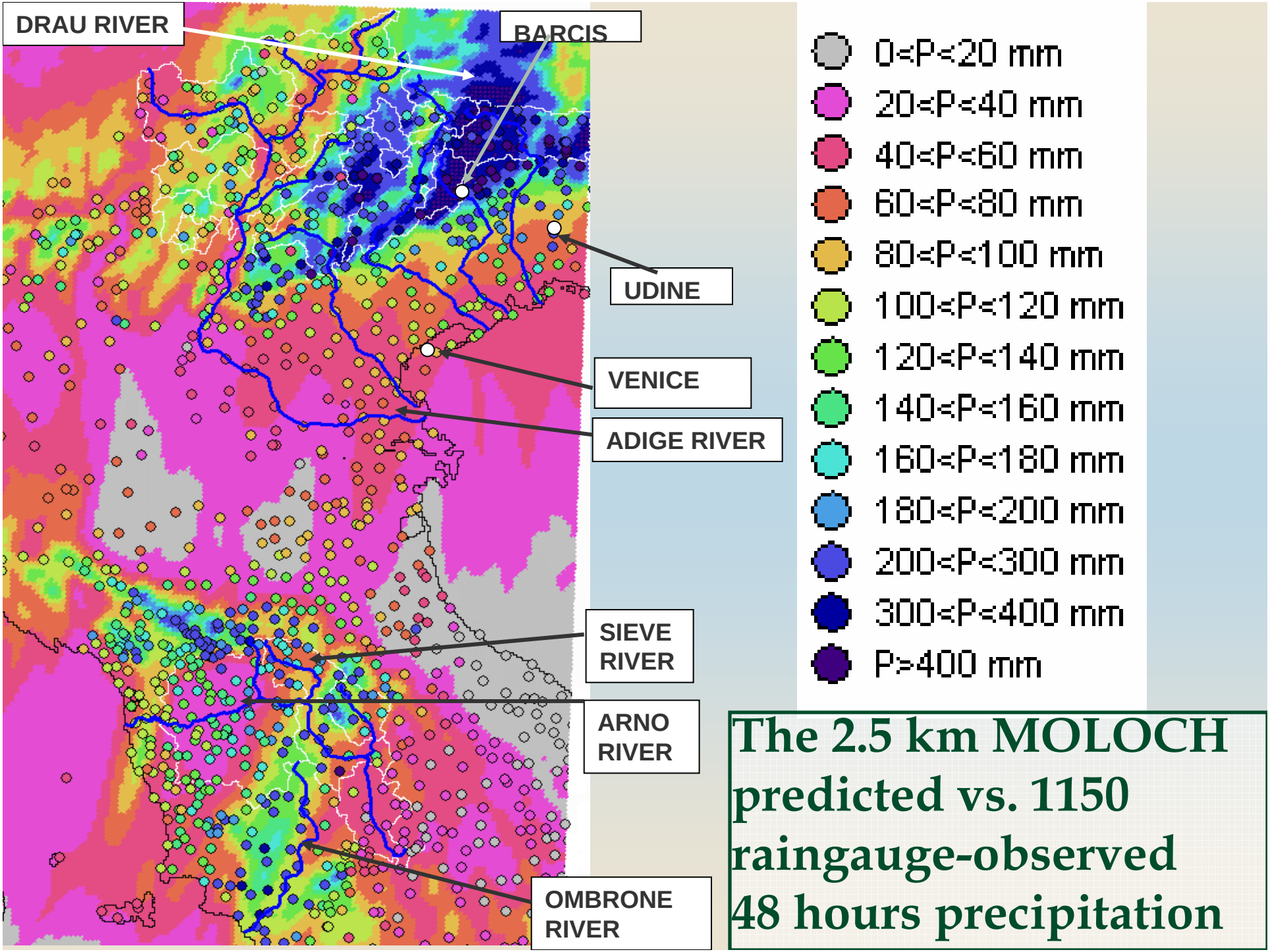
- We re-visited the **november 1966** Italian 'century flood', a widespread **storm and flood event**, which affected Florence, in central Italy and the towns of Trento and Venice in north-eastern Italy
- A **deterministic GCM-MMM-Hydrological** model chain was setup in '***forecast***' mode to investigate the meteorological and hydrological factors which caused the flood [1]
- Then we implemented an **ECMWF-EPS** $\Rightarrow$ **Hydrological** model **HEPS to identify suitable members** to be selected for an **operational dynamic downscaling**

- [1]*Malguzzi, Grossi, Buzzi, Ranzi & Buizza, JGR, 2006*

48 hours accumulated precipitation:
08:00 UTC 03-11-1966 - 08:00 UTC of 05-11-1966

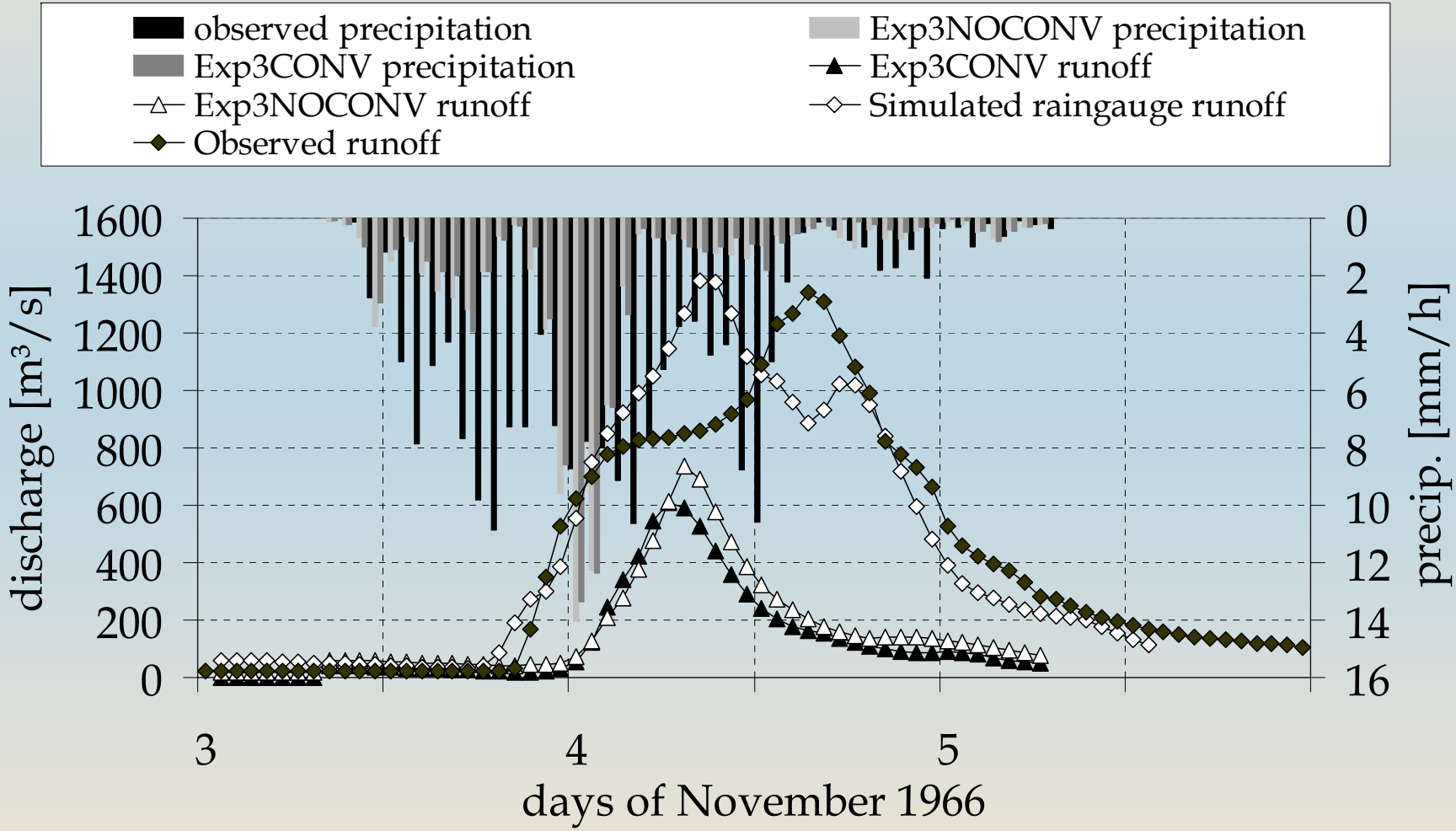
Data were collected by the former Italian National Hydrographic Service


ECMWF-GCM TL511L60 deterministic analysis and forecast
I.C.
B.C.
Hydrostatic BOLAM-MMM 30 km
2 nov
3 nov
4 nov
5 nov
Spin-up
12 GMT 1 Nov. 66
BOLAM self-nesting 7.5 km
Non-hydrostatic
MOLOCH 2 km
The deterministic
GCM-MMM-Hydrological
model chain
Period of accumulation of precipitation
DIMOSOP 250 m flood model
3 nov 06 GMT
Period of flood forecast
5 nov 06 GMT

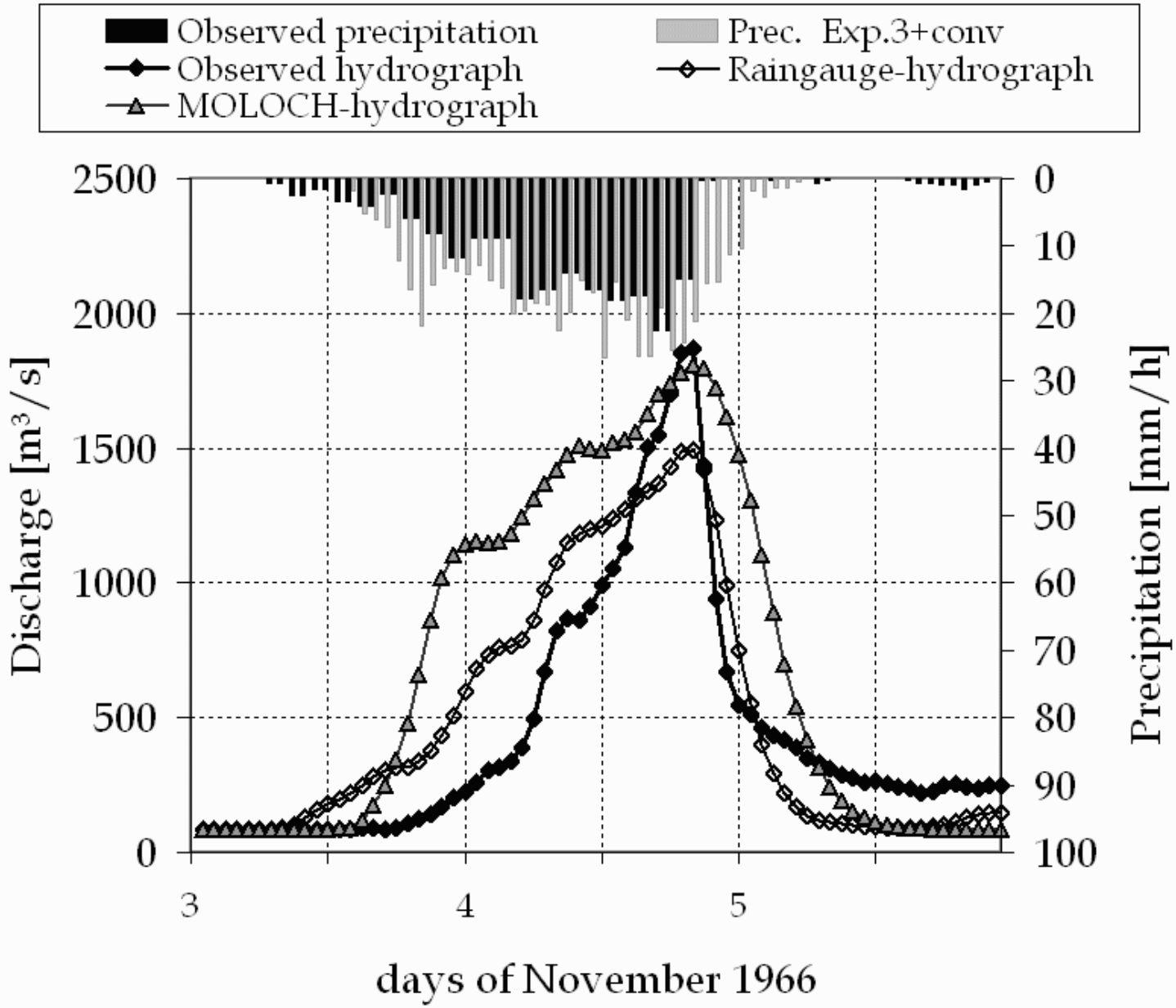


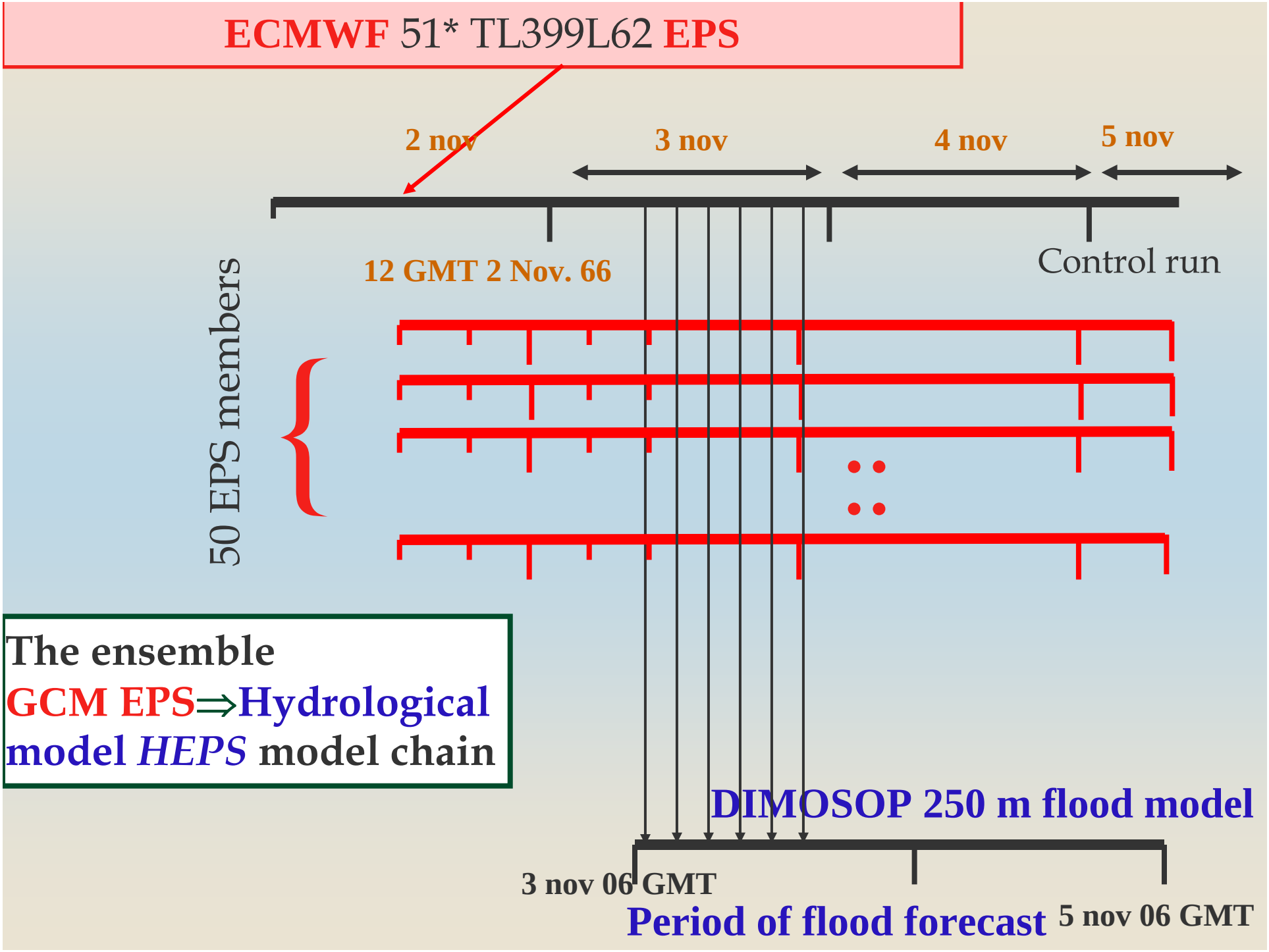
The 2.5 km MOLOCH predicted vs. 1150 raingauge-observed 48 hours precipitation

Sieve River at Fornacina



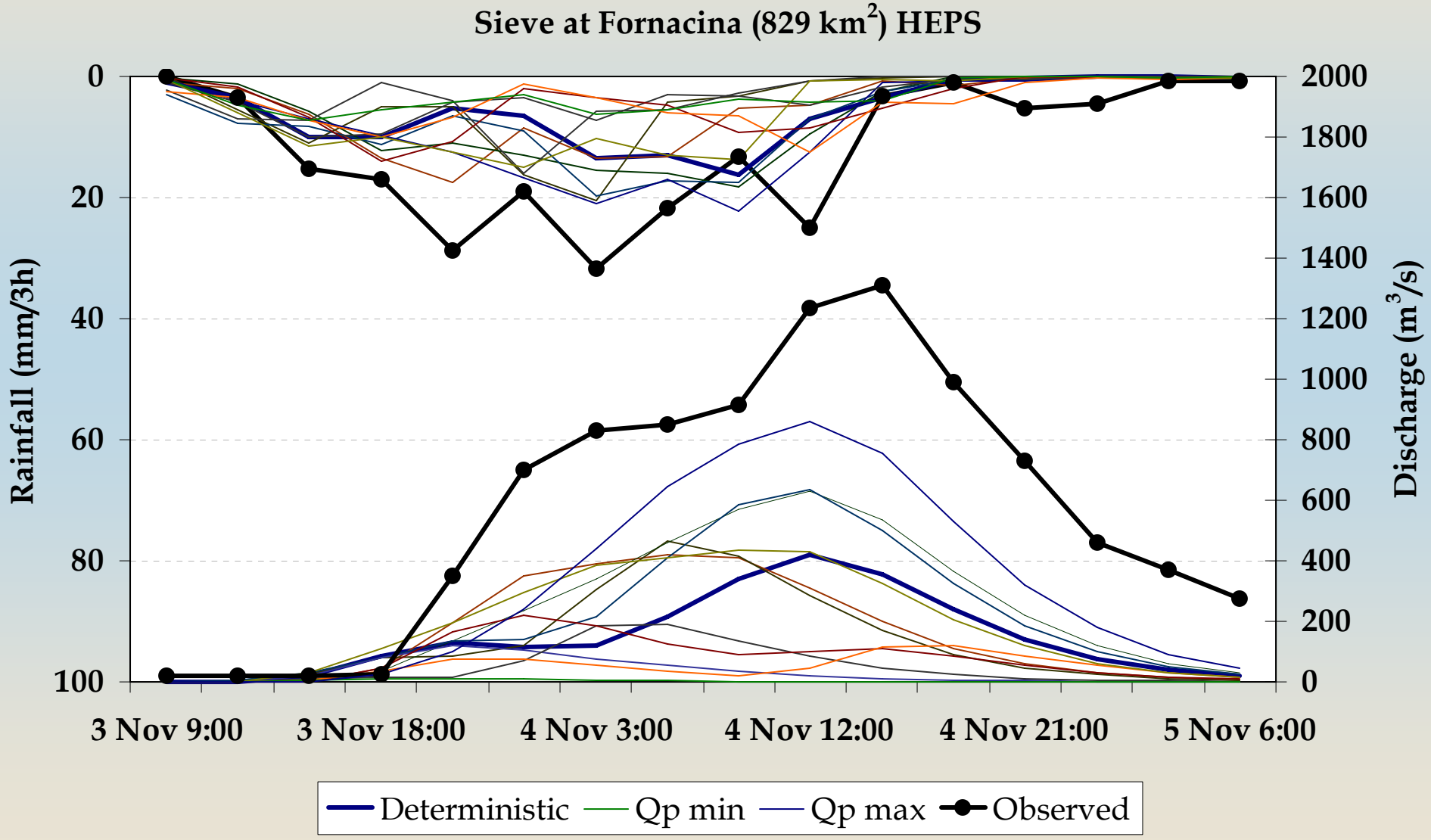
Cellina at Barcis [392 km²]




ECMWF 51* TL399L62 EPS
2 nov
3 nov
4 nov
5 nov
12 GMT 2 Nov. 66
Control run
50 EPS members
The ensemble
GCM EPS⇒Hydrological model *HEPS* model chain
DIMOSOP 250 m flood model
3 nov 06 GMT
Period of flood forecast
5 nov 06 GMT

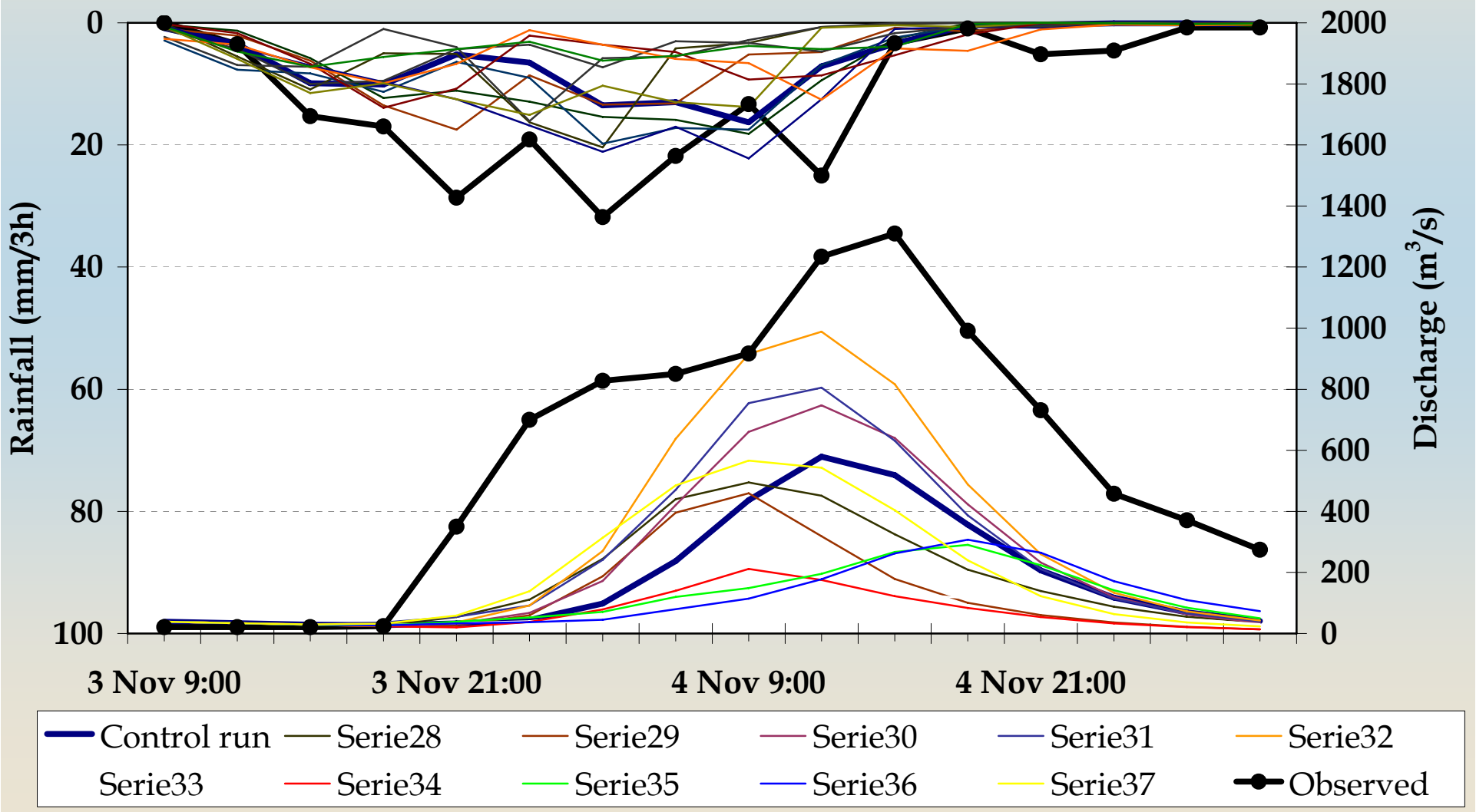
HEPS members *(10/50 shown here)*

Lumped model



HEPS Statistics – distributed model

PRECIP	Sieve a Fornacina	
Mean	85	mm
dev.st	17	mm
max	126	mm
min	50	mm
Observed	191	mm



HEPS statistics
Lumped model

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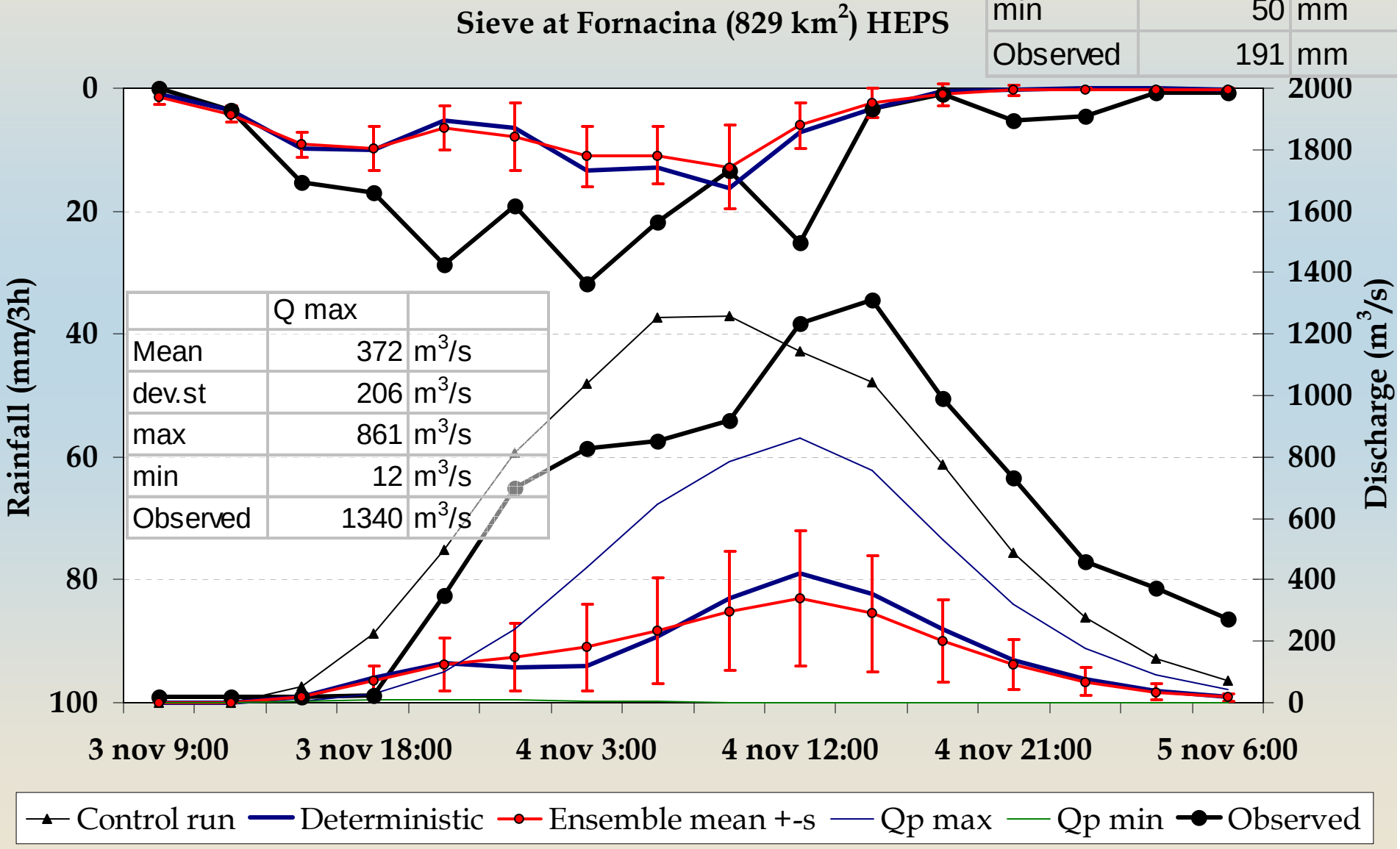
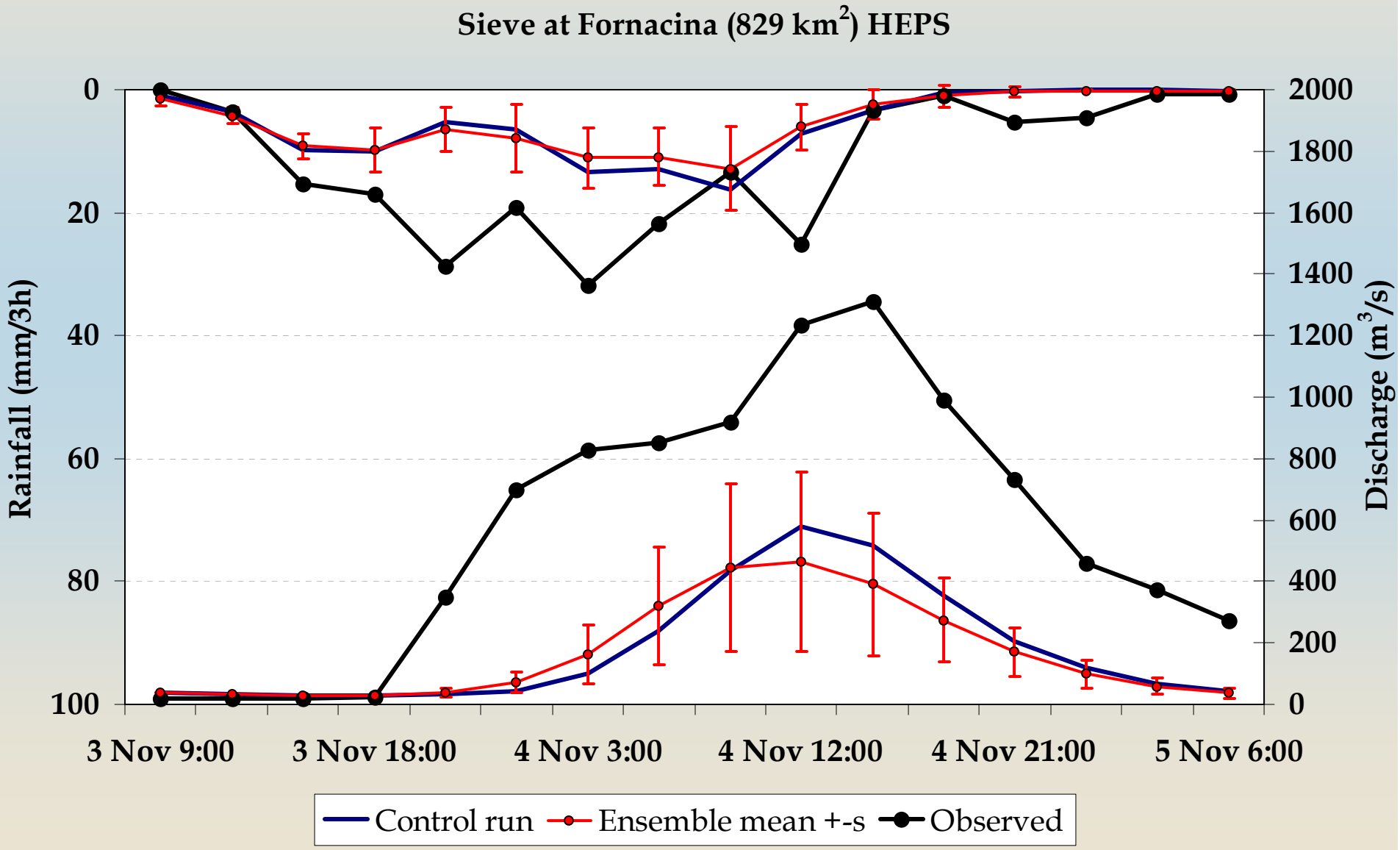


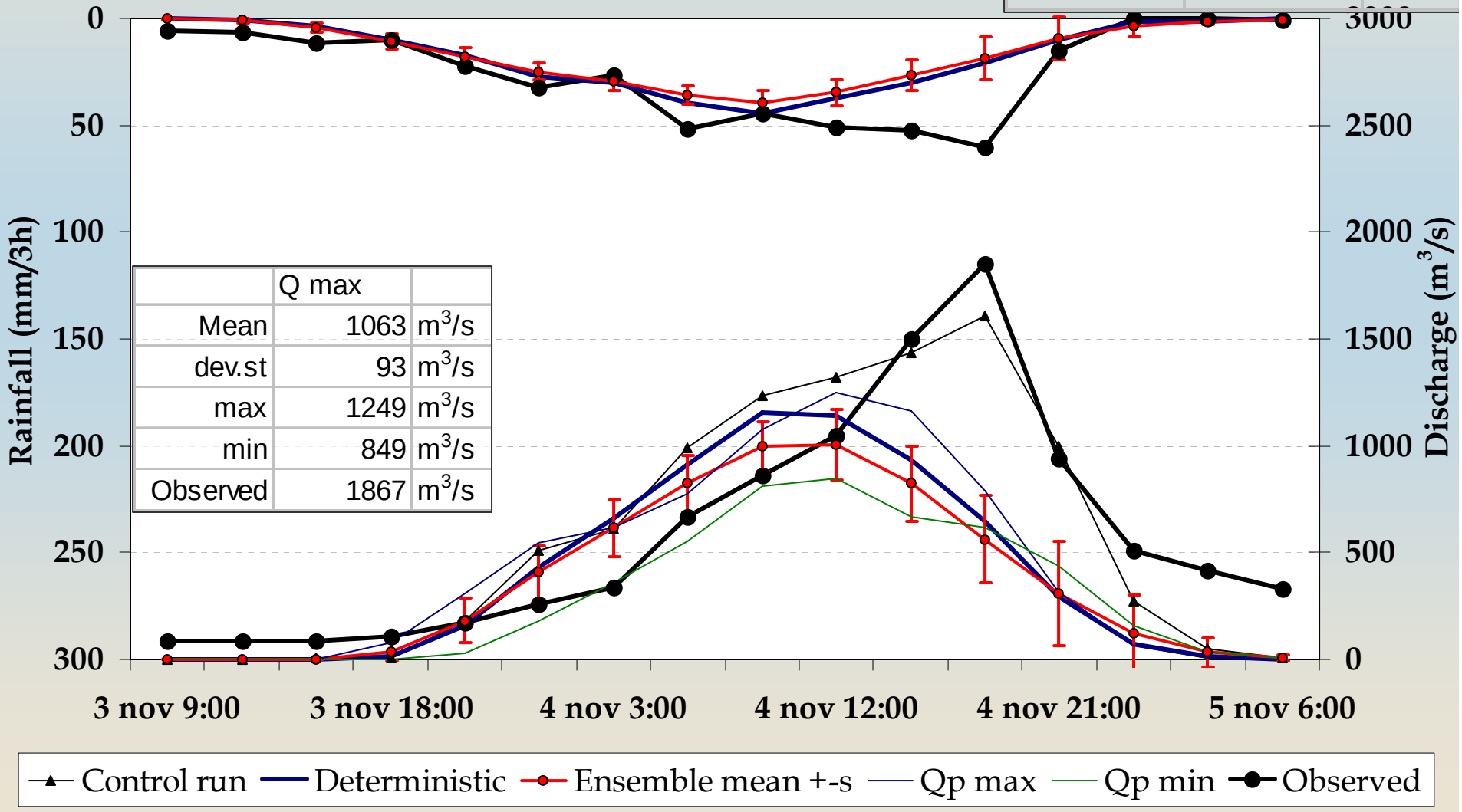
	Q max	
Mean	372	m^3/s
dev.st	206	m^3/s
max	861	m^3/s
min	12	m^3/s
Observed	1340	m^3/s

HEPS Statistics– distributed model



HEPS statistics lumped model

	Cellina at Barcis	
Mean	258	mm
dev.st	27	mm
max	320	mm
min	186	mm
Observed	391	mm



	Q max	
Mean	1063	m3/s
dev.st	93	m3/s
max	1249	m3/s
min	849	m3/s
Observed	1867	m3/s

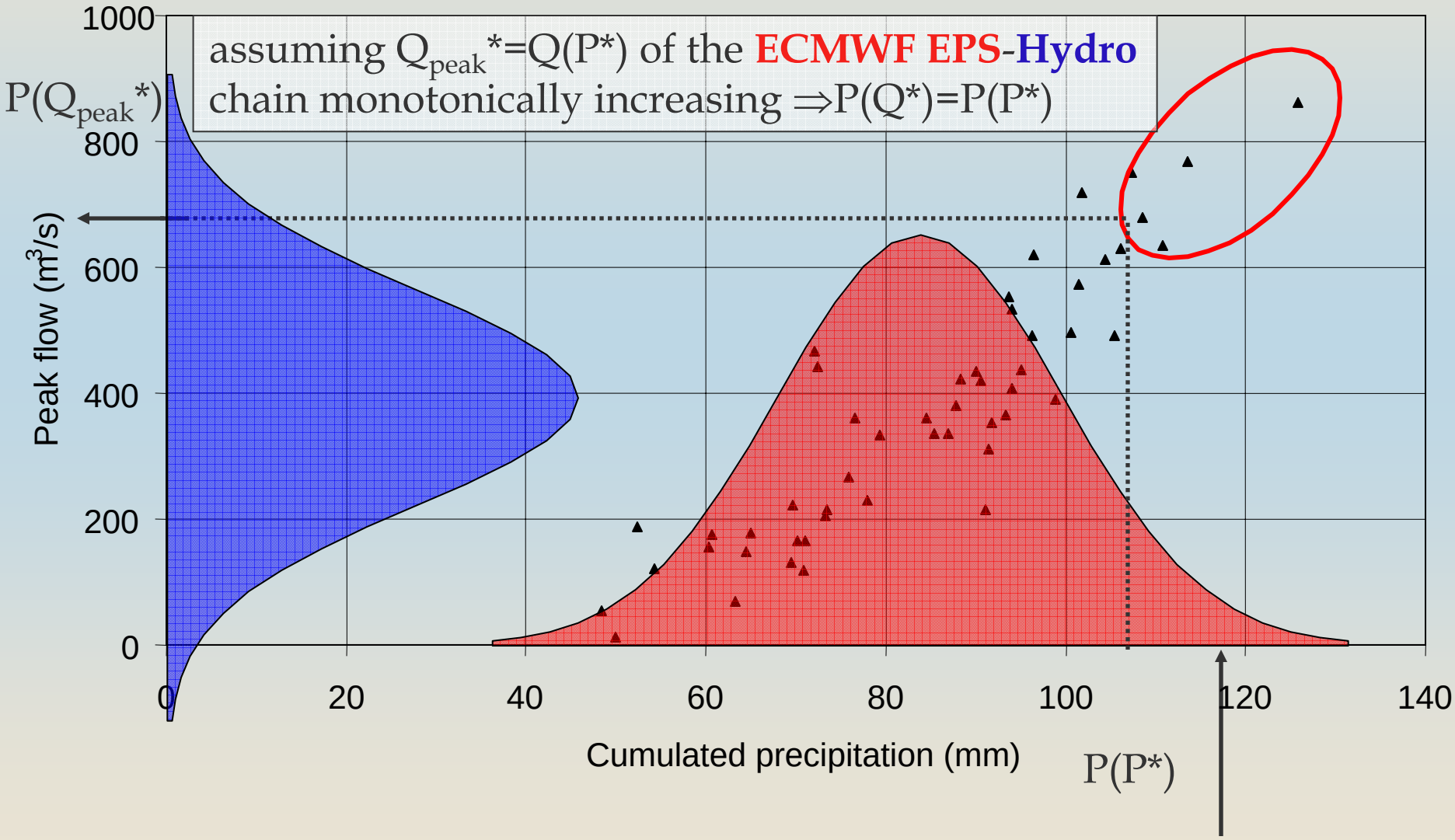
We observe that:

- **ECMWF TL511L60** ->**MMM**->**Hydro** deterministic chain underestimates floods in central Italy (convective rain), but is fair for the Alps (orographic rain). Good timing

- **ECMWF TL399L62 EPS t+18…t+66**-> **Hydro EPS** chain underestimates floods especially in central Italy but also in the Alps. Good timing

- $\Rightarrow$ to correct the bias a GCM->MMM->Hydro EPS is needed. A few members need to be selected for an operational non-hydrostatic mesoscale model downscaling. **Which members do we need to select?** A strategy for this selection is needed (test in MAP D-PHASE 2007).

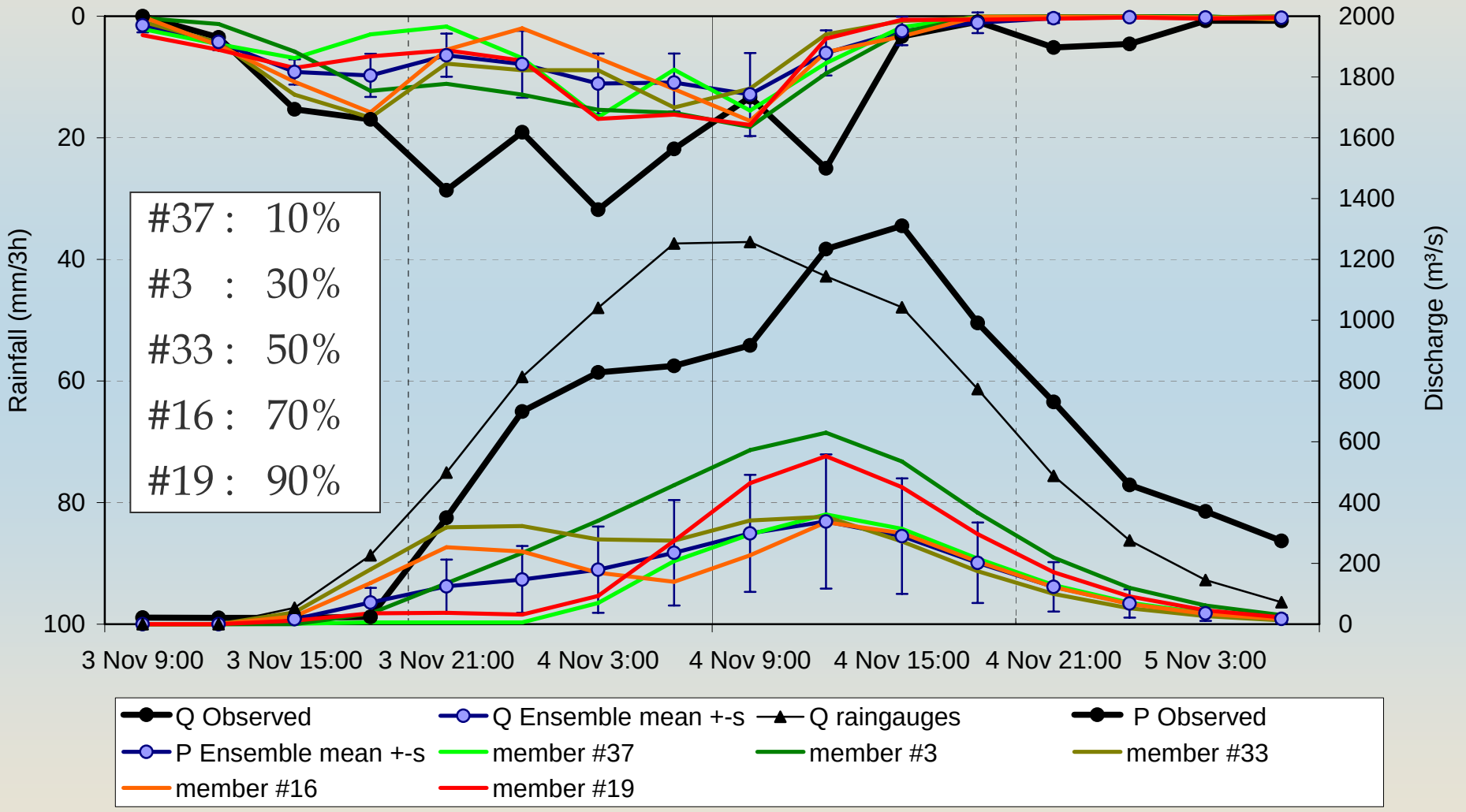
Sieve at Fornacina



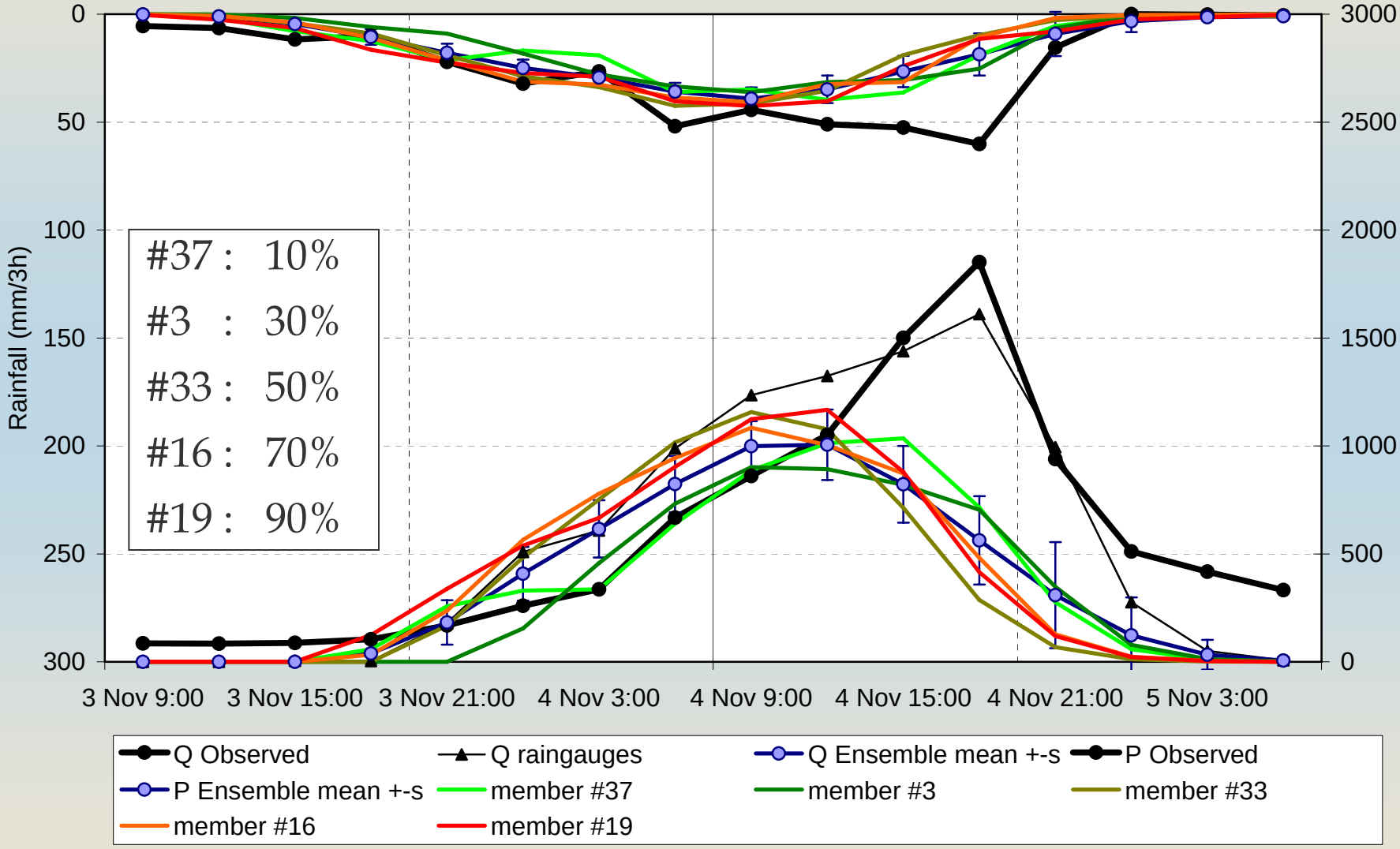
Strategy

- **First the area surrounding a riverbasin where a given fraction of the members of the meteorological GCM ensemble *areal rainfall* exceeds a threshold level, RA, is defined as a *'target area'*.**
- **Then, a sub-set $N_T \sim 5$ of the $N_{EPS} \sim 50$ GCM ensemble members is selected, such that the *tail (P> .90)* and some *representative quantiles* (e.g. .10, .30, .50, .70) of the CDF of the *flood peak* forecasted for this '*target area*' by the ECMWF-Hydro chain are well represented.**
- …(in perspective) the complete **ECMWF**-MMM-Hydro flood forecasting chain is implemented for these **N_T members**

Sieve at Fornacina (829 km2) HEPS



Cellina at Barcis (392 km2) HEPS



Conclusions

- Precipitation fields and flood peaks forecasted by the ECMWF BOLAM-MOLOCH-DIMOSOP chain for the nov. 1966 extreme event (Arno basin ☹ and the Alps ☺)
- 'target-basin' approach: the aim is to extract key, large-scale meteorological information from a global ensemble systems, to be used to drive a cascade of limited-area meso-scale and hydrological models.
- A dynamic downscaling using mesoscale models is needed to correct the ECMWF bias, especially for convective rain
- For a mesoscale HEPS we suggest to sample the upper tail and representative quantiles of the distribution

Future plans

- consider more cases,
- investigate possible ways to improve the target-basin approach, e.g. by considering different areas where precipitation is averaged, and by enlarging the number of selected members from 5 to 10.
- the possibility to select the representative members on the basis of not only total precipitation but also of other forcing characteristics, such as the peak rainfall intensity or the hyetograph shape, will also be investigated
- the quality of the HEPS forecasting cascade will be assessed considering longer forecast ranges.