

DRIHM

DISTRIBUTED RESEARCH INFRASTRUCTURE
FOR HYDRO-METEOROLOGY

EXAMPLE OF BENEFITS OF MODEL CHAINING

Olivier Caumont



e-infrastructure

*DRIHM is co-funded by the EC
under the 7th Framework Programme*

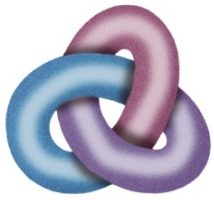


POLITÉCNICA






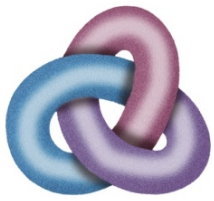
advancing the frontiers





Contents

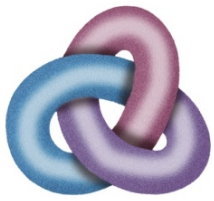
-  *A use case: the Genoa 2011 flash flood*
-  *Chained meteorological and hydrological models (for the sake of simplicity, no extension of the chaining to hydraulic and impact models)*
-  *Emphasis on benefits gained from using the DRIHM e-Science environment*



➔ The Genoa 2011 Case

The Set of Models

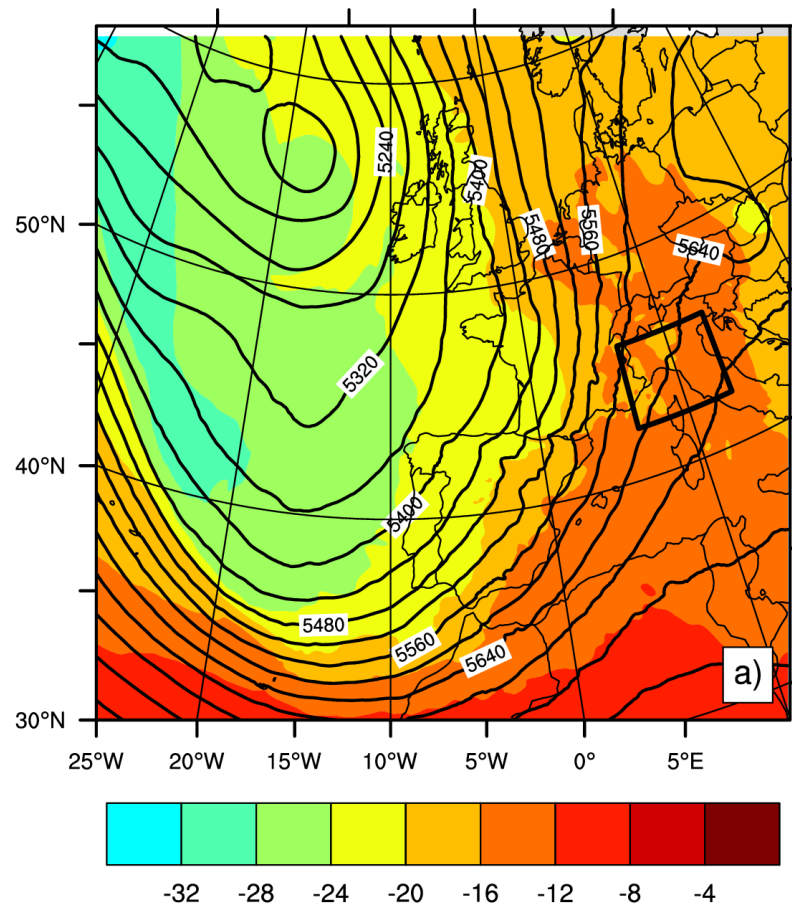
Benefits Gained from DRIHM
e-Science Infrastructure



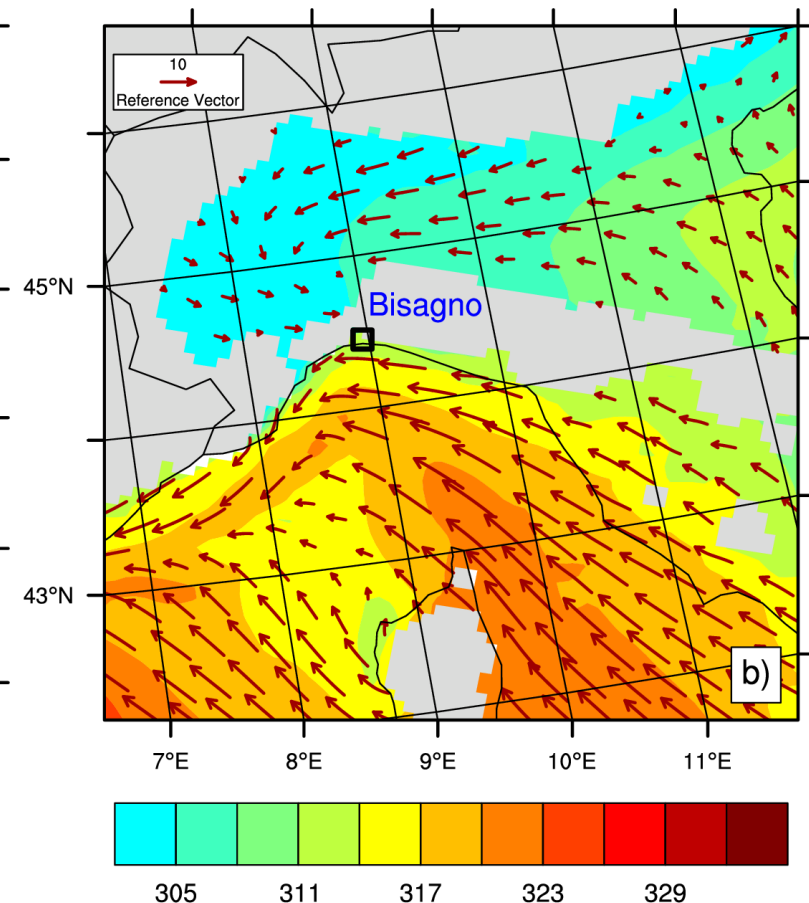
The Genoa 2011 case: meteorological description

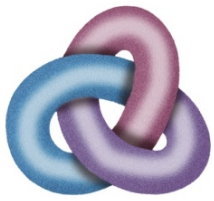
IFS large-scale analysis at 00 UTC on 4 November 2011

Temperature ($^{\circ}\text{C}$) and geopotential height (m)
at 500 hPa



Potential temperature (K) and winds (m/s) at
950 hPa

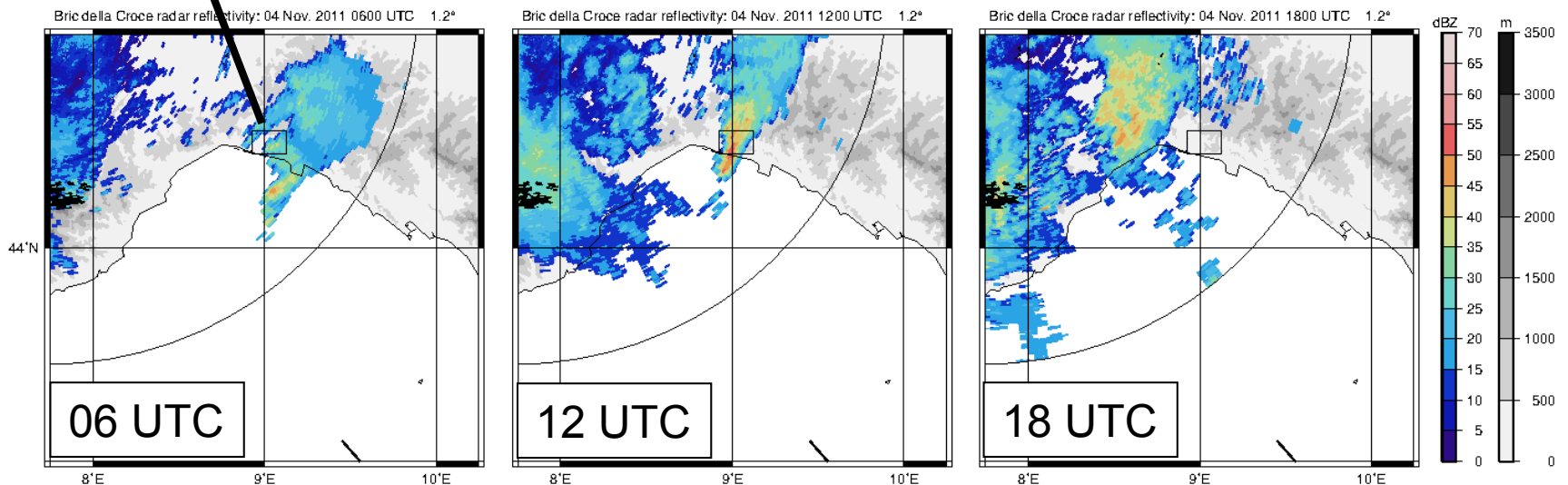


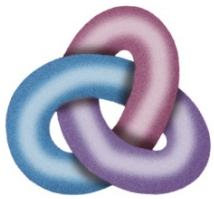


The Genoa 2011 case: meteorological description

Bric della Croce radar reflectivity

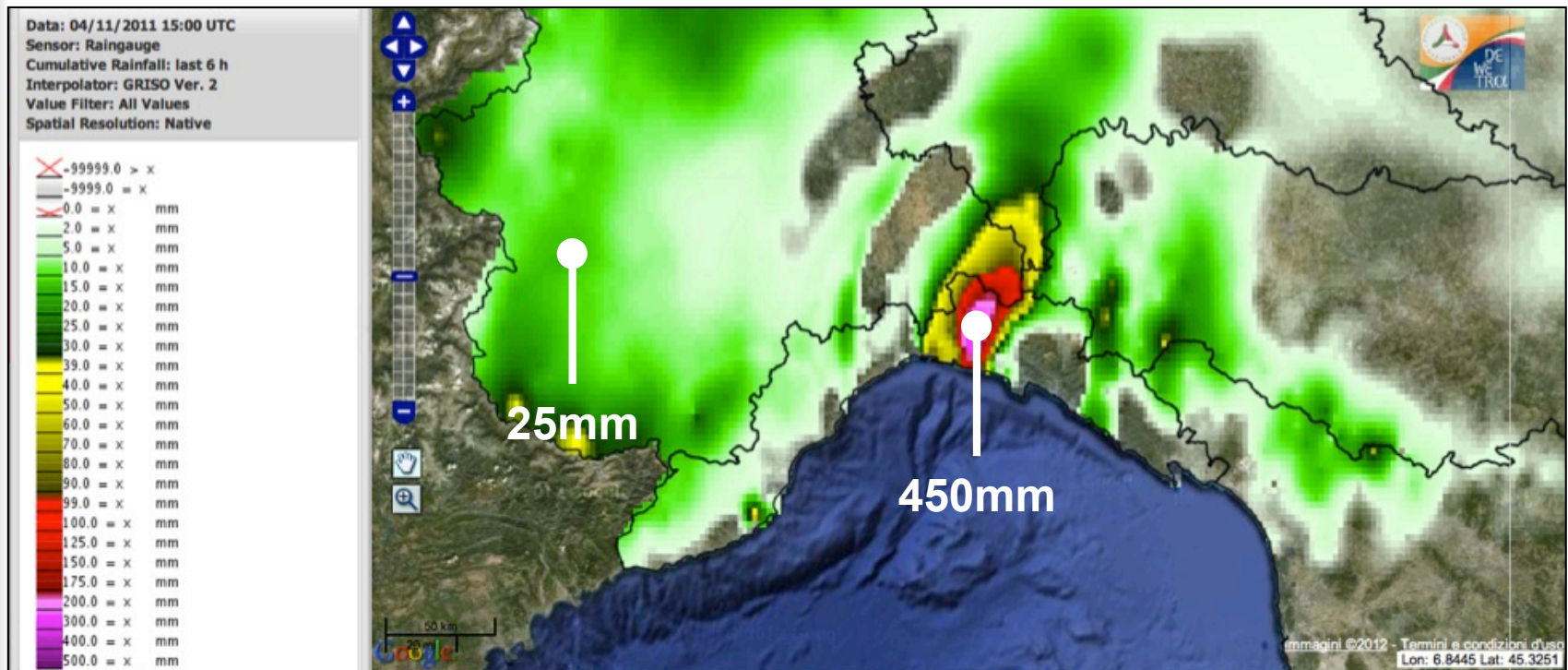
Bisagno
watershed

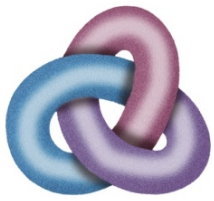




The Genoa 2011 case: meteorological description

Total cumulative rainfall from ICPD raingauge network
between 09 and 15 UTC





The Genoa 2011 case: societal impact

 *The Bisagno creek burst its banks, flooding the city centre*

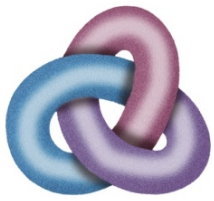
A third of the average annual rainfall (450mm) fell in 6 hours.

Six people were killed.

Trees were uprooted, cars swept away and shopfronts shattered.



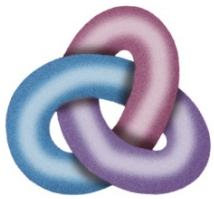
Worst disaster since a similar flood killed 25 people in 1970.



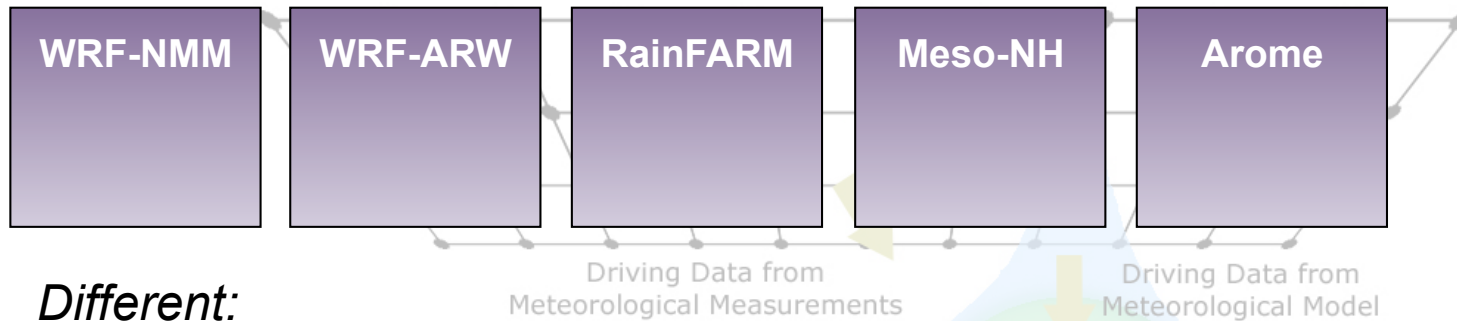
The Genoa 2011 Case

➔ The Set of Models

Benefits Gained from DRIHM
e-Science Infrastructure

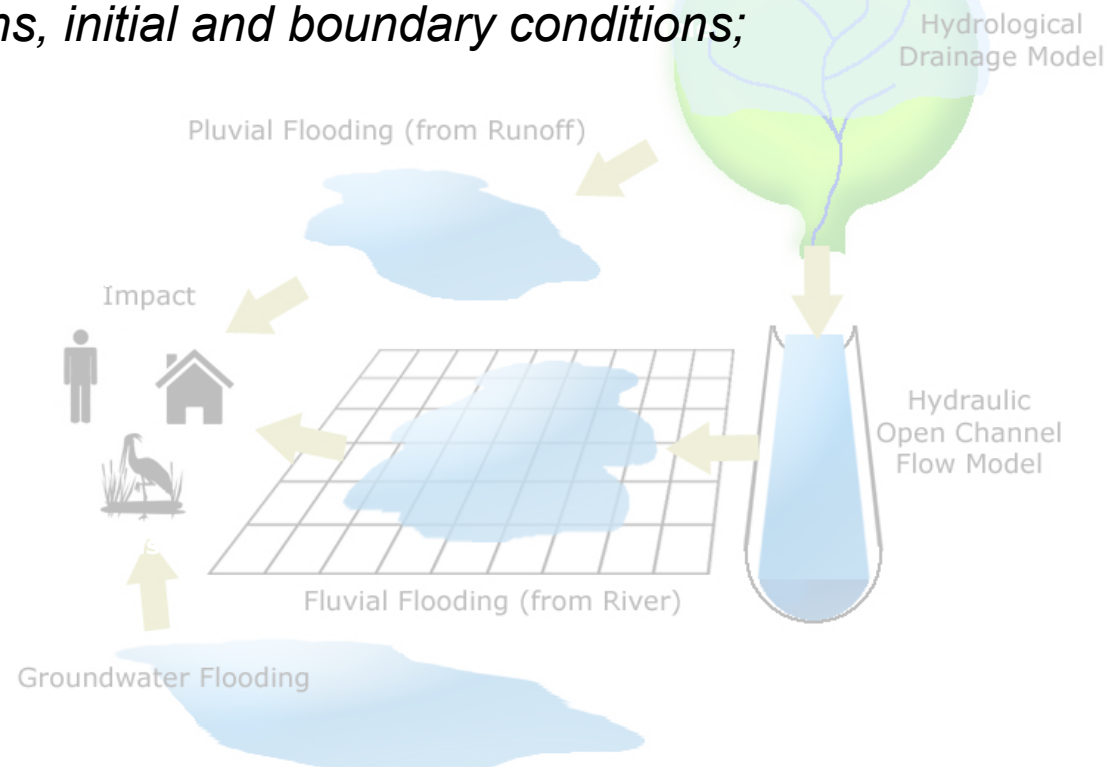


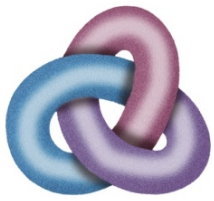
Different atmospheric models



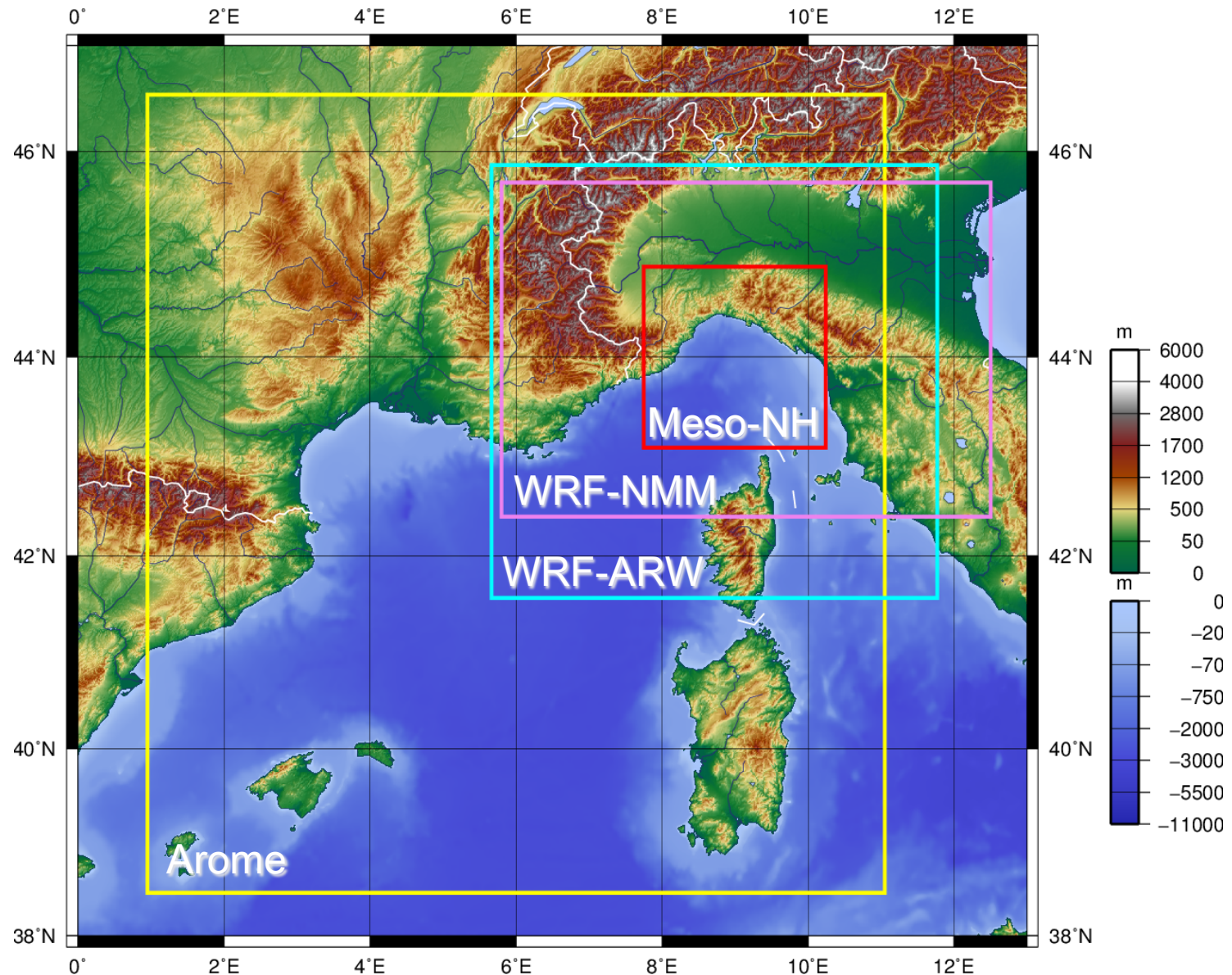
Different:

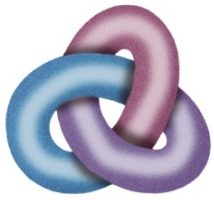
- *Domains, initial and boundary conditions;*



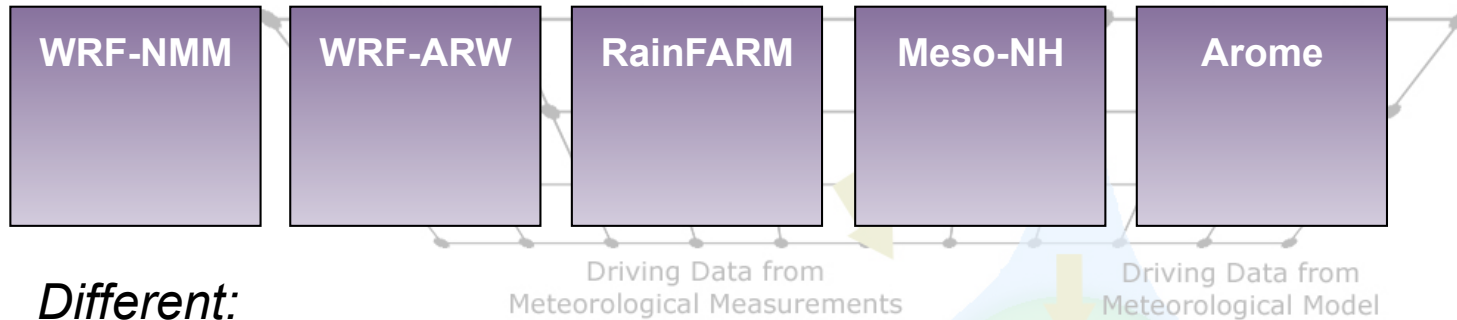


Different atmospheric models: innermost domains





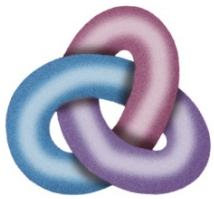
Different atmospheric models



Different:

- *Domains, initial and boundary conditions;*
- *Horizontal resolutions: from 2.5 km to 500 m;*
- *Projections;*
- *Types: stochastic (RainFARM) vs. physically-based (the others);*
- *Dynamical cores and/or physics (for physically-based models);*
- *Forecast modes: deterministic (one scenario) vs. probabilistic (several scenarios);*
- *Input and output formats.*





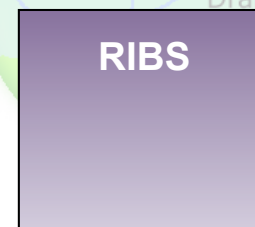
Different hydrological models



Pluvial

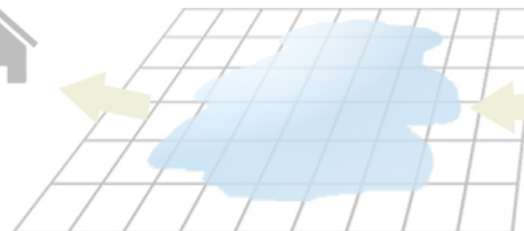


(off)



Hydrological
Drainage Model

Impact



Hydraulic
Open Channel
Flow Model

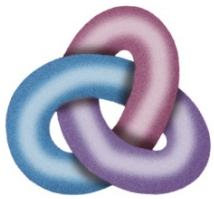


Different:

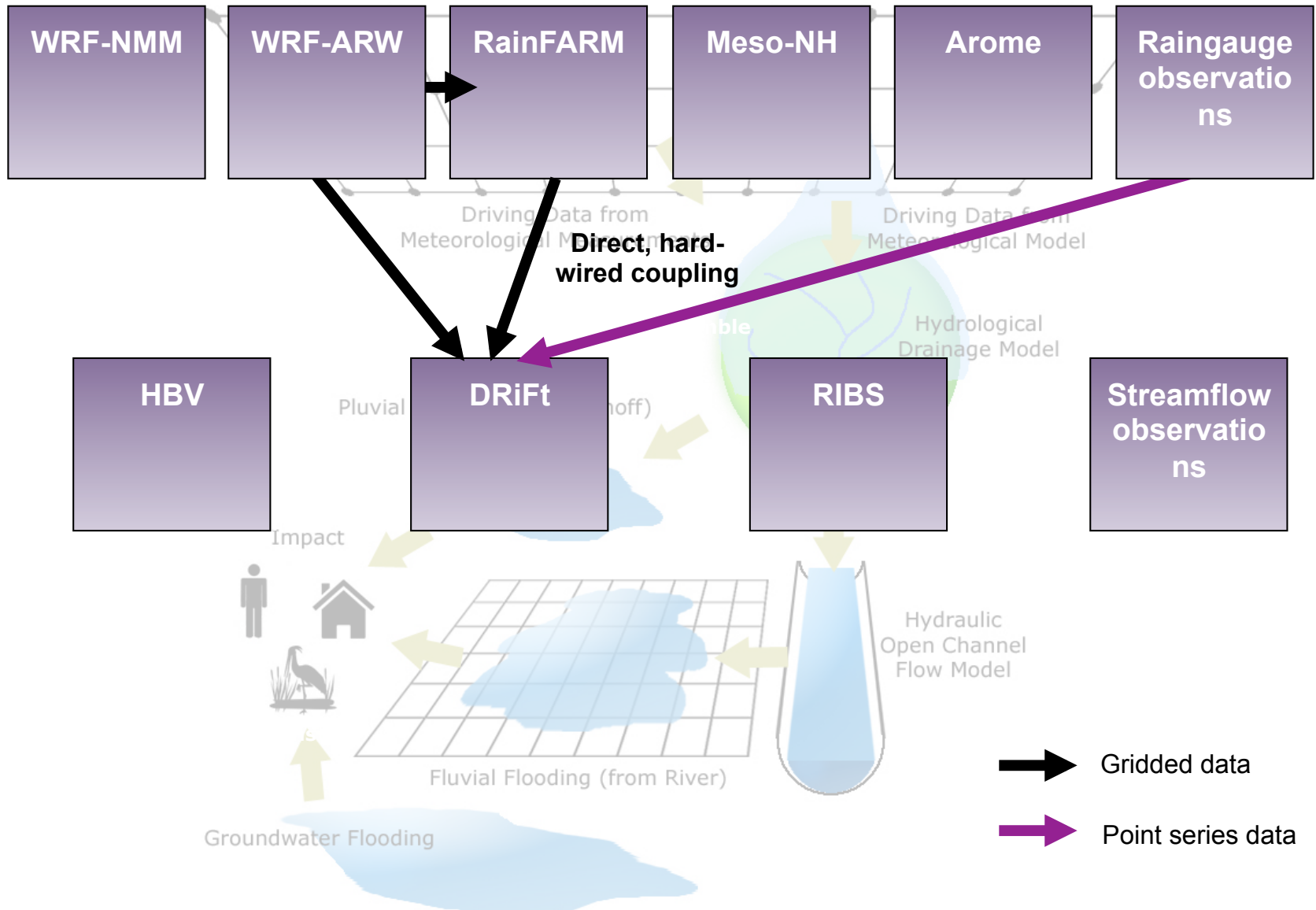
- *Physics;*
- *Forecast modes: deterministic (one scenario) vs. probabilistic (several scenarios);*
- *Input and output formats.*

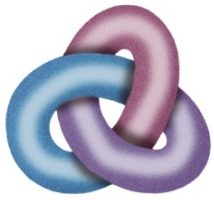
Groundwater Flooding





Model chaining without DRIHM

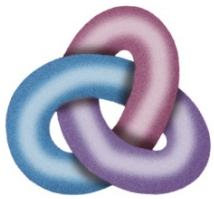




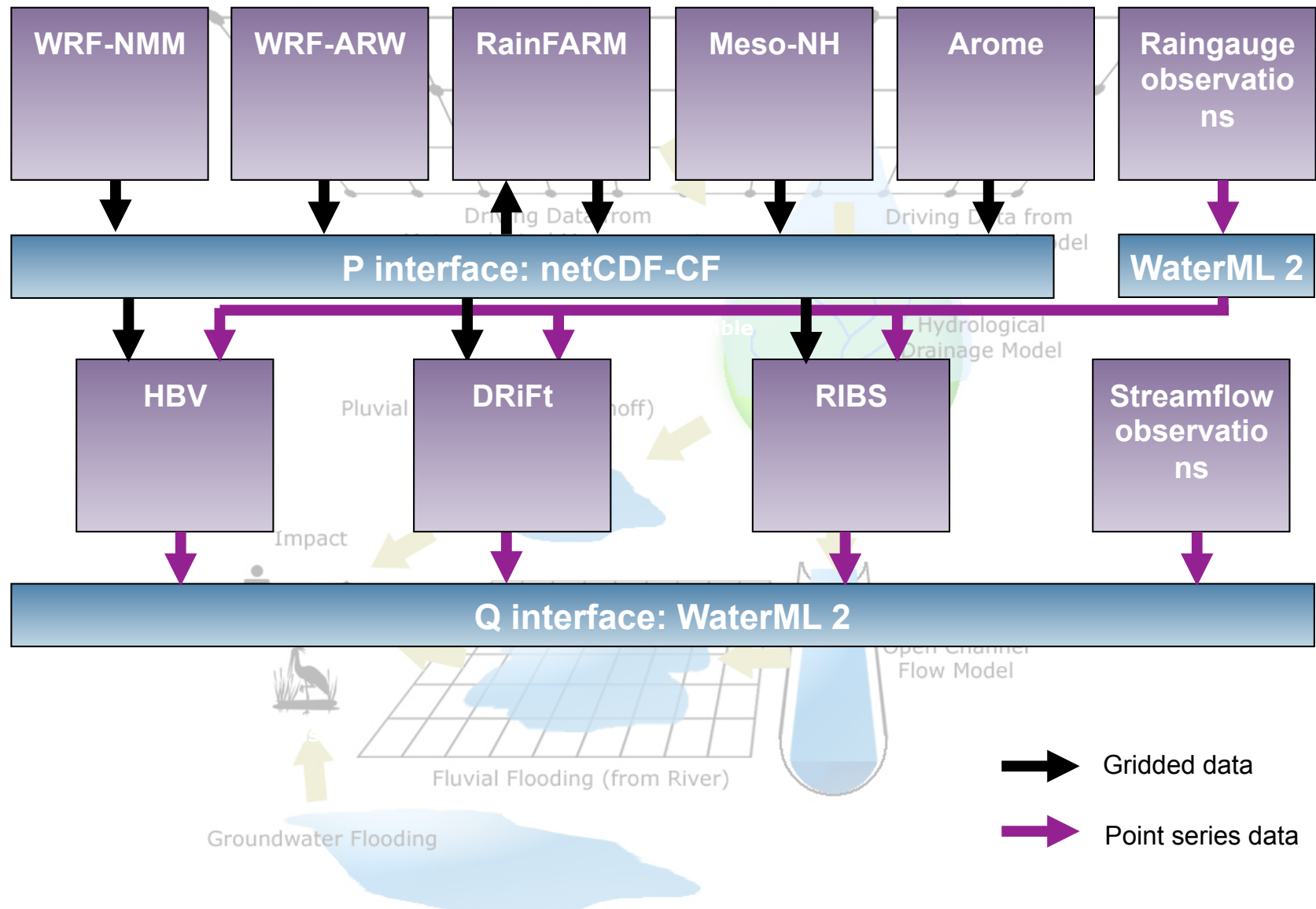
The Genoa 2011 Case

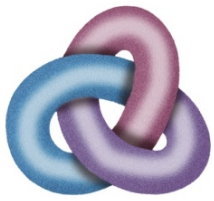
The Set of Models

➔ Benefits Gained from DRIHM
e-Science Infrastructure



Model chaining with DRIHM



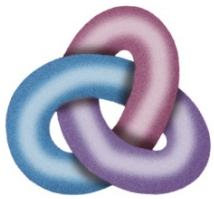


Summary of model configurations

Rain source	Description	Ensemble members	Resolution (km)	DRiFt and HBV runs	RIBS runs
Observations	Raingauge measurements	1		1	31
WRF-NMM	IC & BC: IFS	1	1.3	1	31
WRF-ARW	IC & BC: IFS	1	1.0	1	31
Arome	IC AEARO; BC: PEARP	8	2.5	8	248
Meso-NH	IC & BC: Arpege	10	0.5	10	310
Meso-NH	IC & BC: IFS	10	0.5	10	310
RainFARM	Downscaling of WRF-ARW	20	0.7	20	620
Total		51		51	1581

 *More than 1600 different hydrometeorological scenarios*

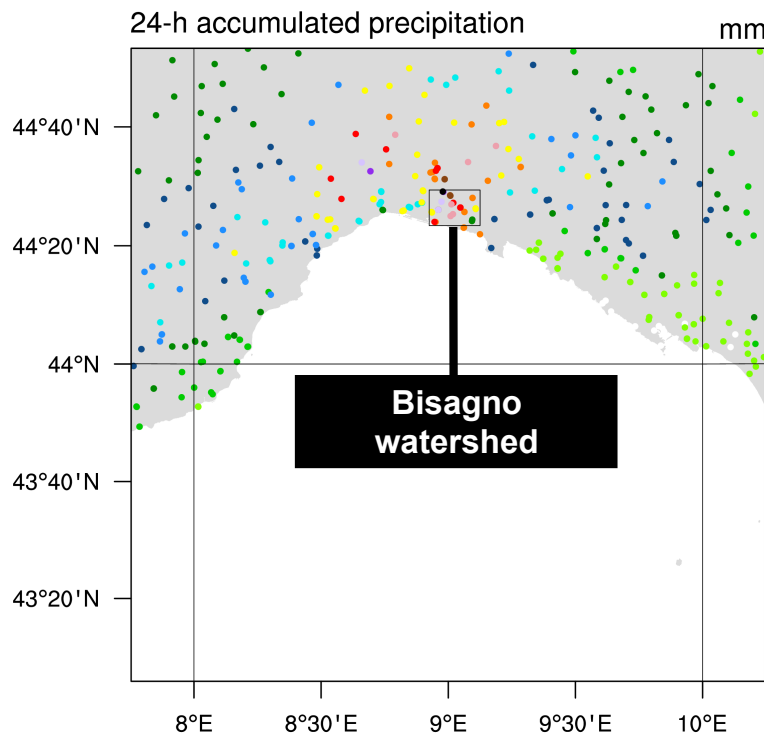
IC: Initial conditions; BC: Boundary conditions



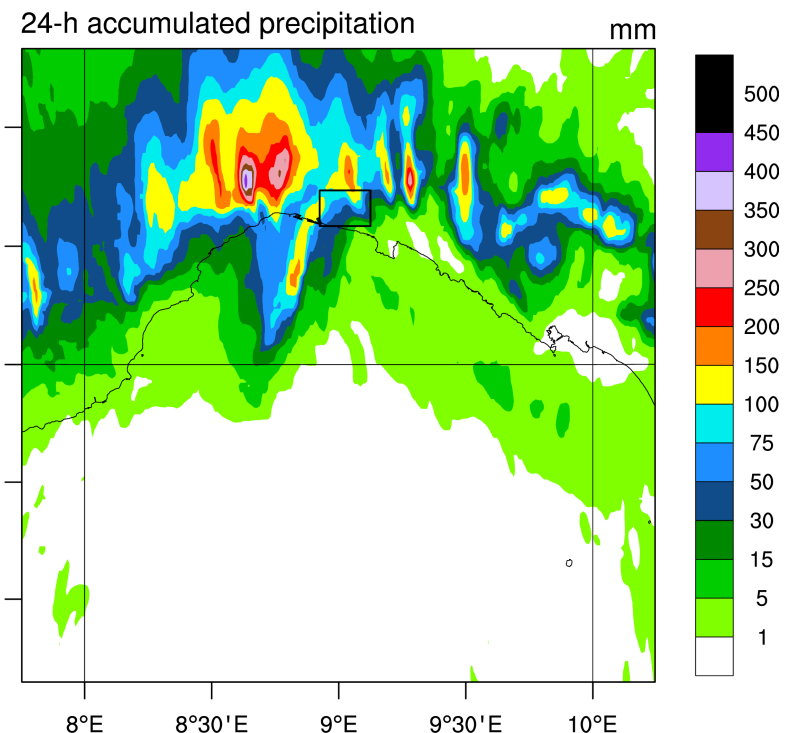
Meteorological scenarios

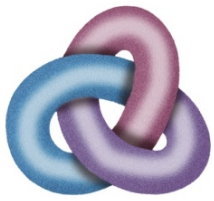
- 50 high-resolution, multi-model scenarios
- 3 different ensembles from 2 different ensemble prediction systems
- In the same format (netCDF-CF)
- Allowing processing by many free, off-the-shelf post-processing and visualization softwares (here the NCAR Command Language – NCL)
- Directly comparable with WaterML 2.0 observations

Raingauge observations



WRF83

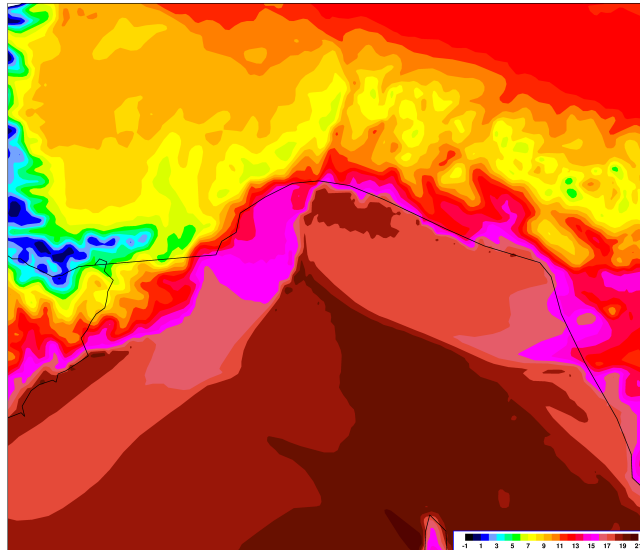




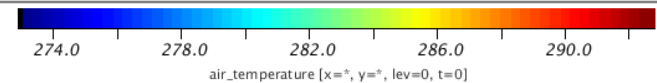
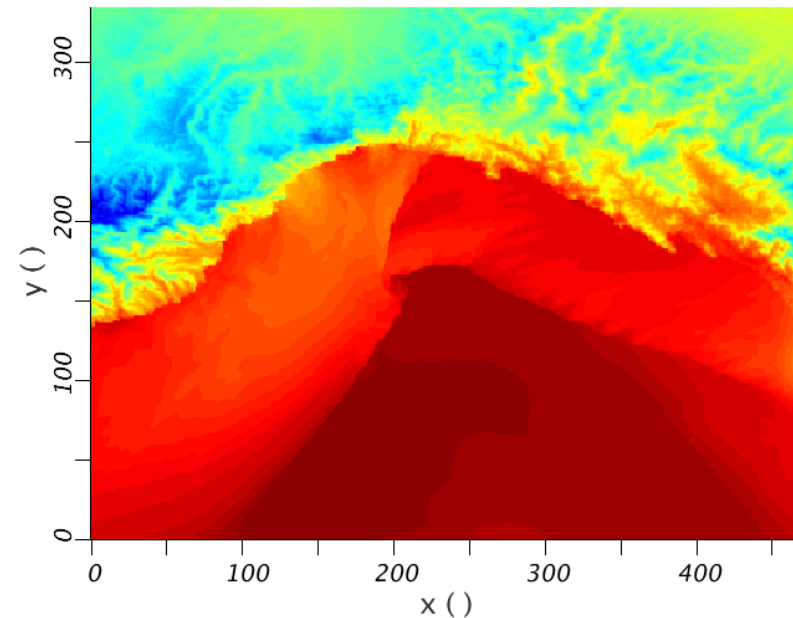
Comparison of different models without DRIHM

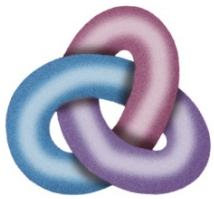


2-m temperature (°C) - Arome D06D_0 2011/11/04 01 UTC (Forecast +7)

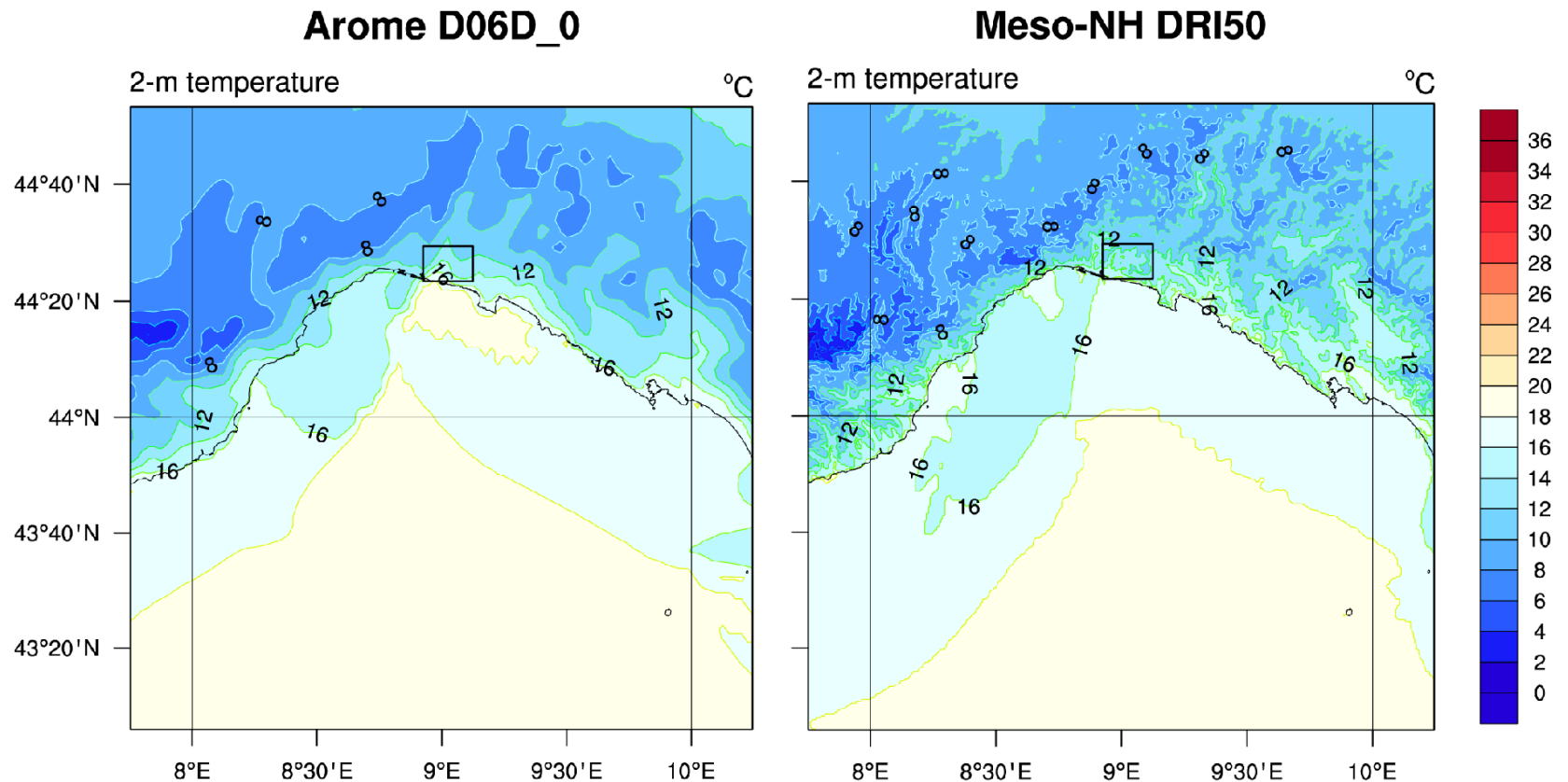


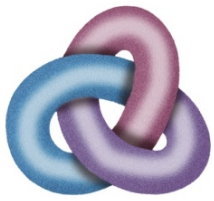
Meso-NH DRI50
2-m air temperature (K)





Comparison of different models with DRIHM





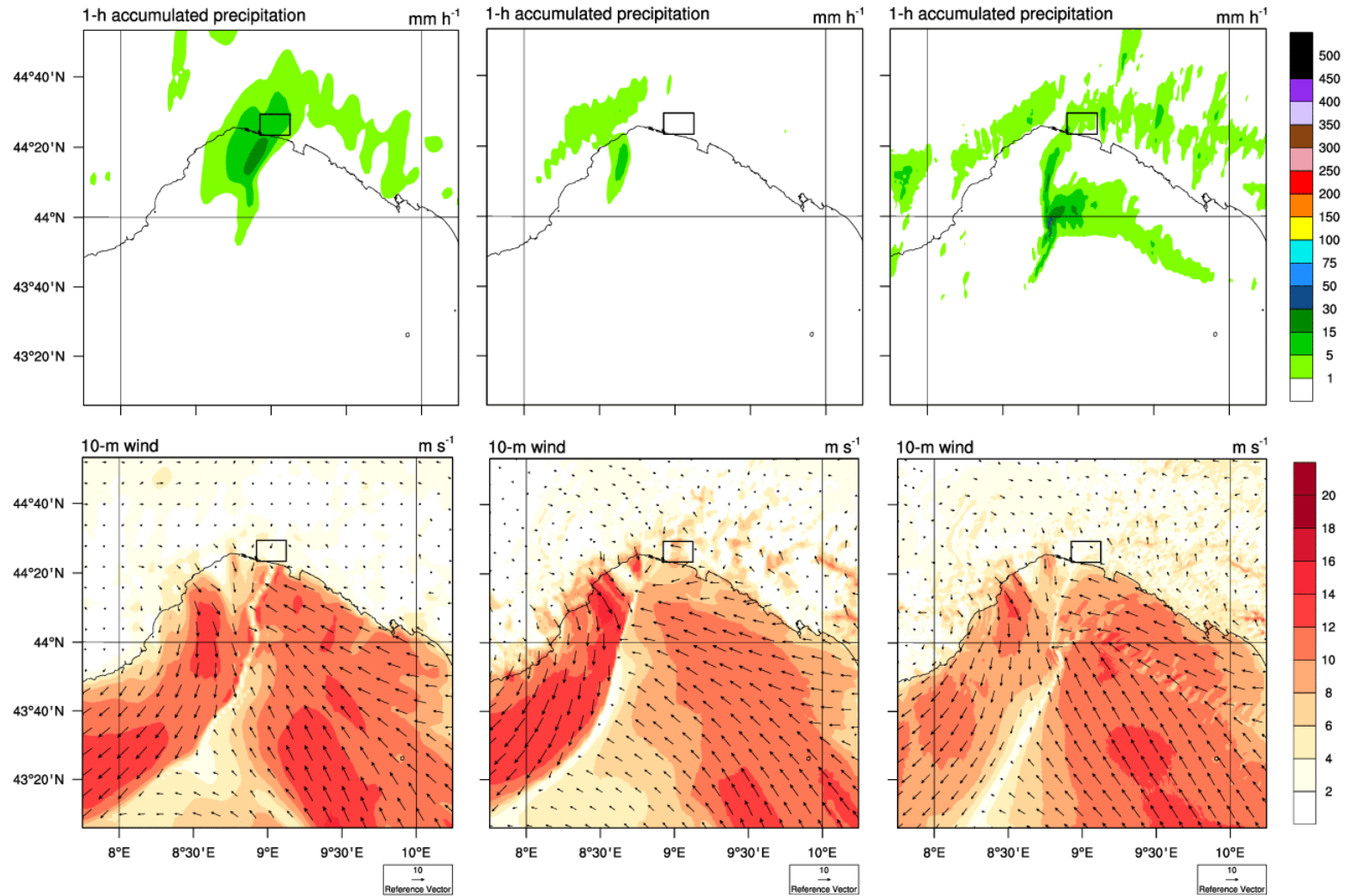
Comparison of model fields

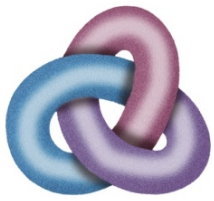


Arome D06D_6 - 01 UTC 4 Nov 2011

WRF83 - 01 UTC 4 Nov 2011

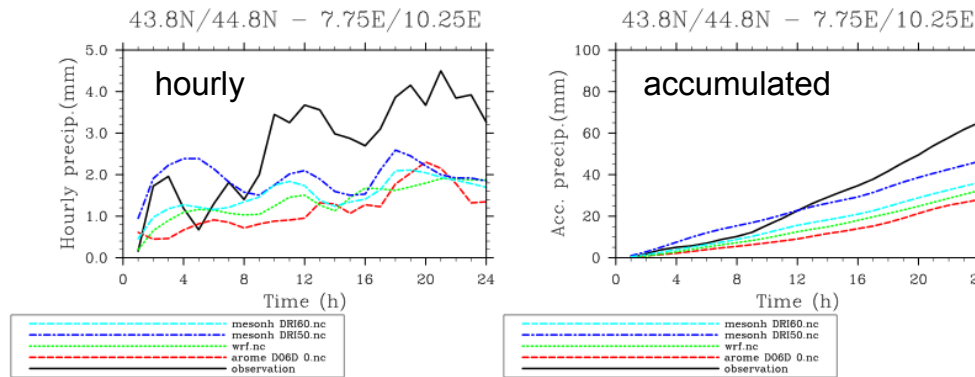
Meso-NH DRI54 - 01 UTC 4 Nov 2011





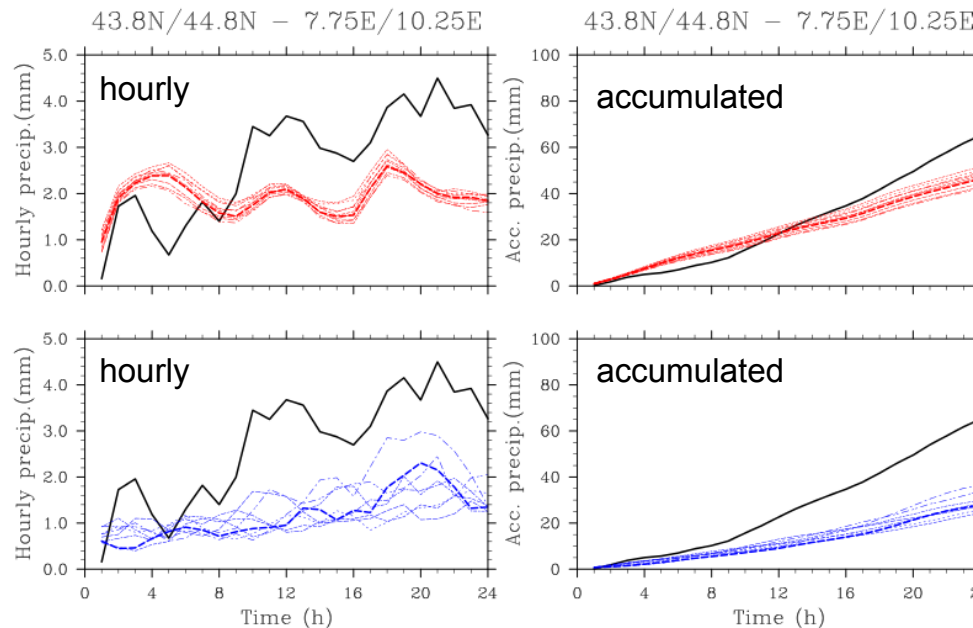
Comparison of rainfall time series

 *Rainfall time series averaged over the largest common domain*



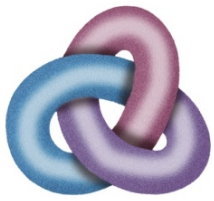
Rainfall time series for
raingauge observations and
different simulations

 *Ensembles*



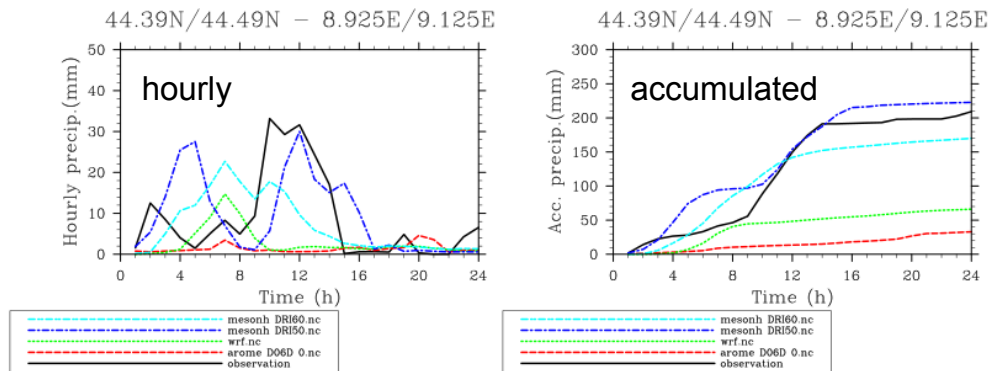
Rainfall time series for
raingauge observations and
Meso-NH ensemble (DRI5X)

Rainfall time series for
raingauge observations
and **Arome ensemble**



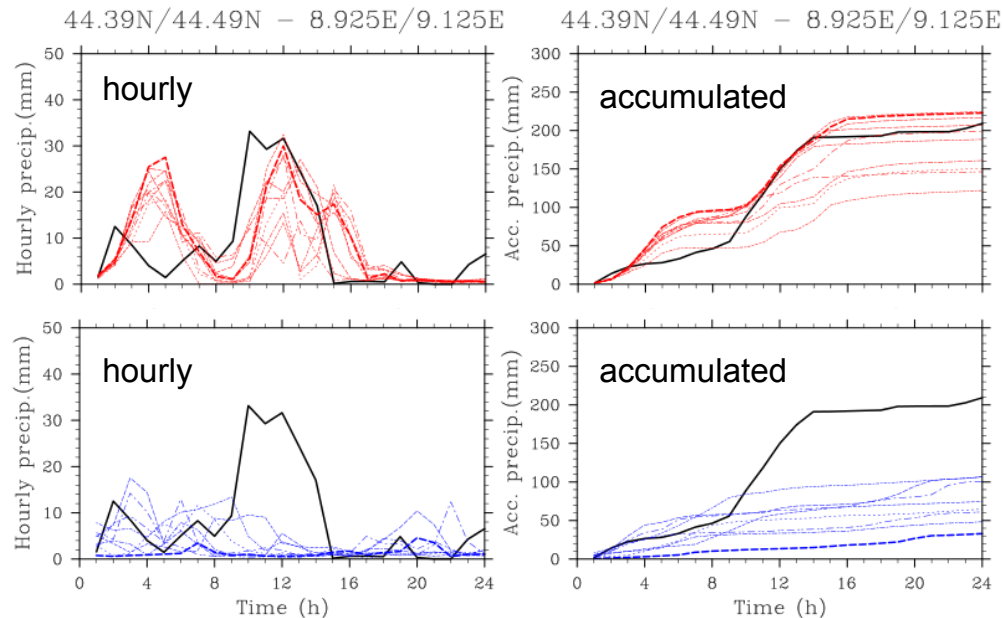
Comparison of rainfall time series

Rainfall time series averaged over the Bisagno catchment



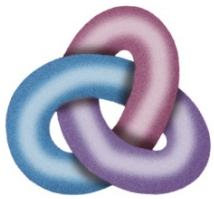
Rainfall time series for
raingauge observations and
different simulations

Ensembles

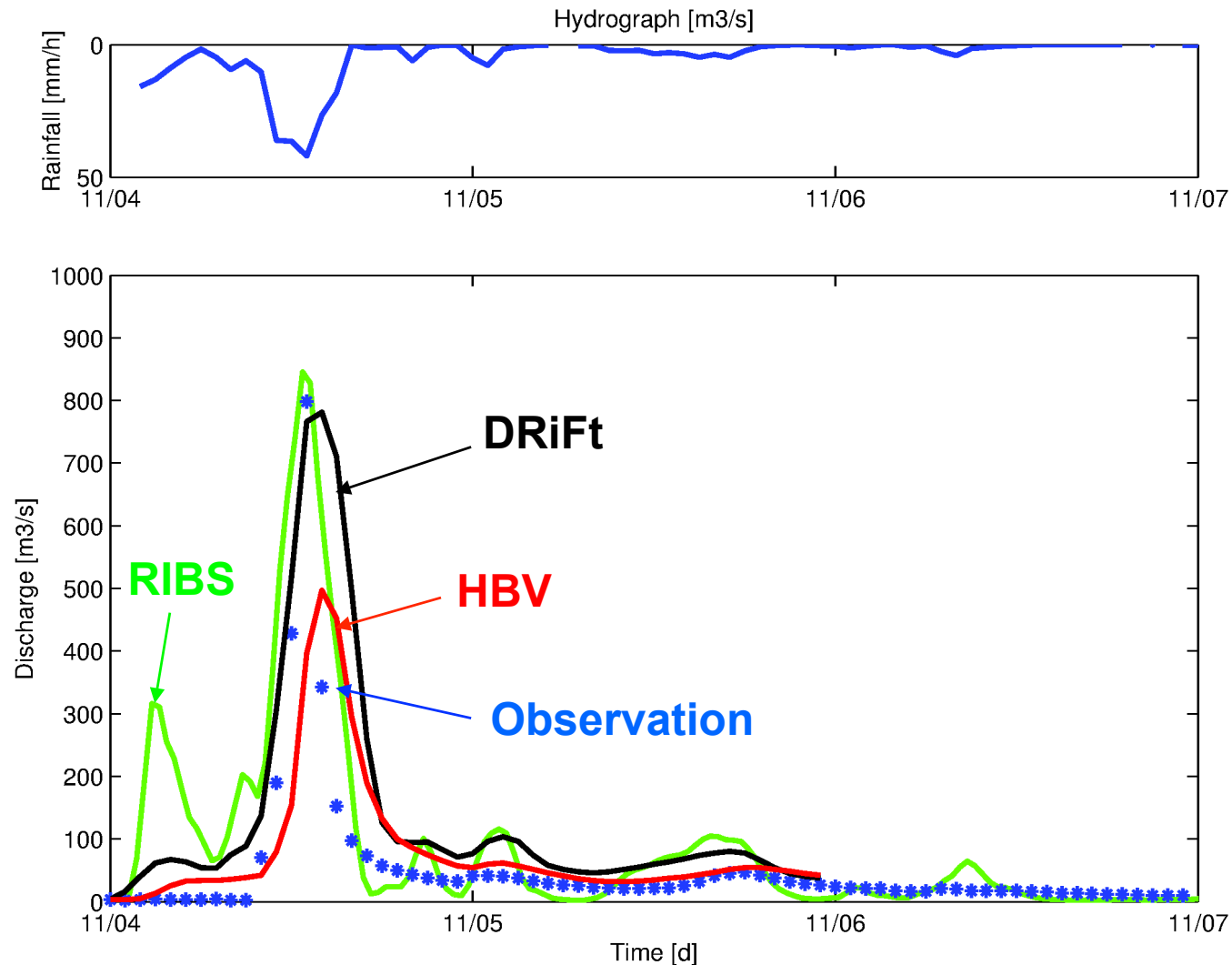


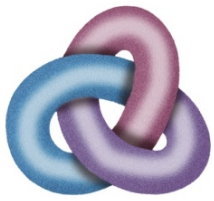
Rainfall time series for
raingauge observations and
Meso-NH ensemble (DRI5X)

Rainfall time series for
raingauge observations
and **Arome ensemble**



Comparison of discharge time series driven by observations

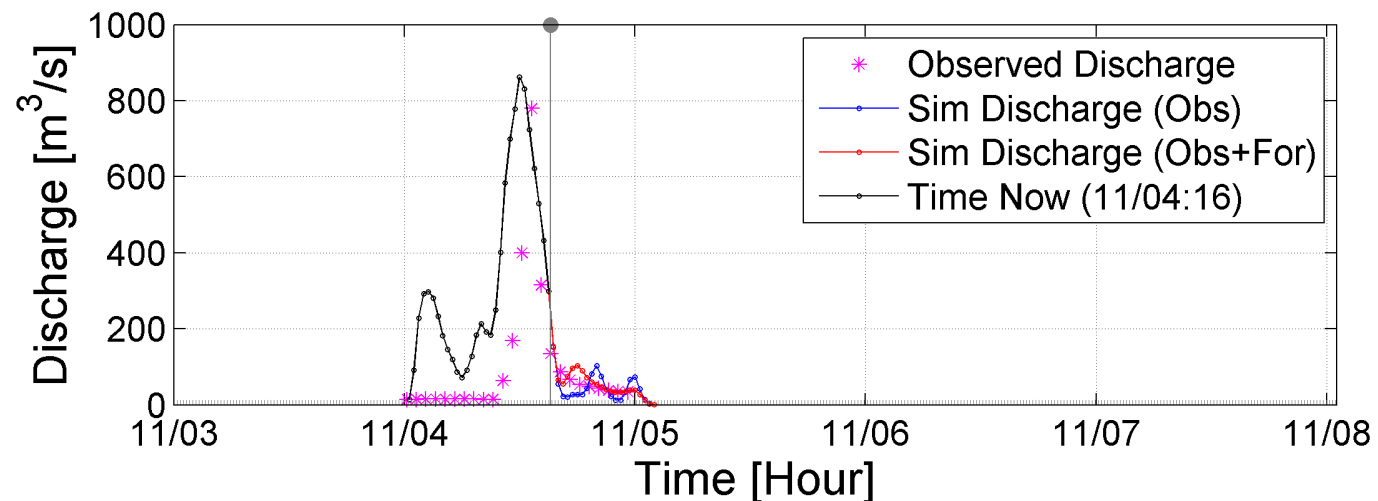
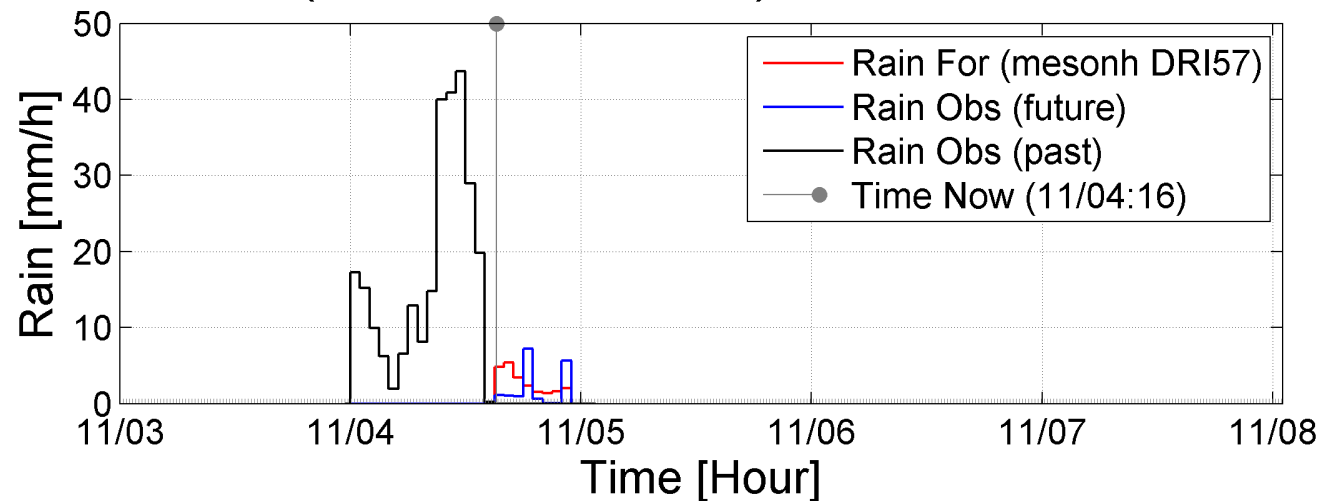


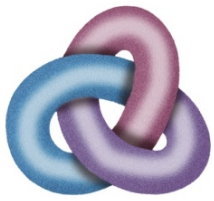


Full hydrometeorological chains

 Summarizing all the information produced by a chain in one plot

RIBS(mesonh DRI57-7408):20111104-20111105

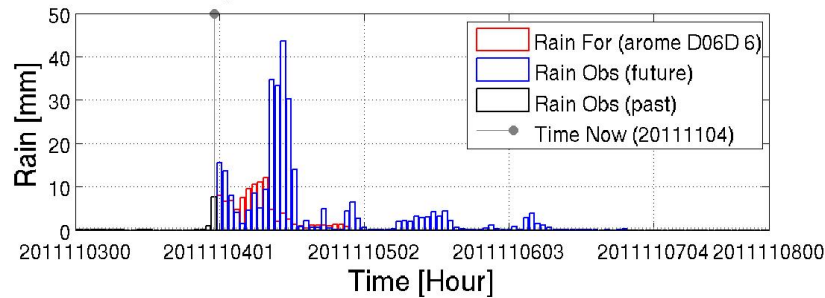




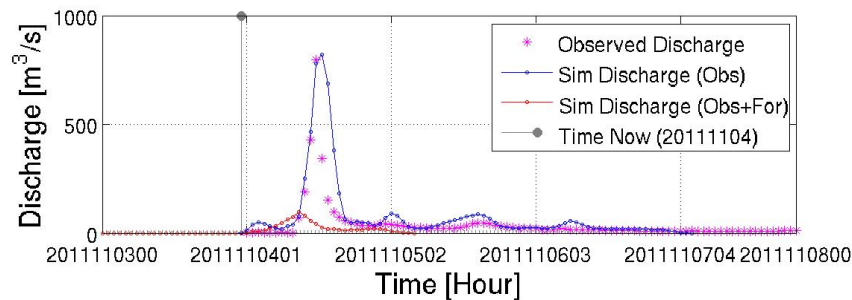
Comparison of different rainfalls



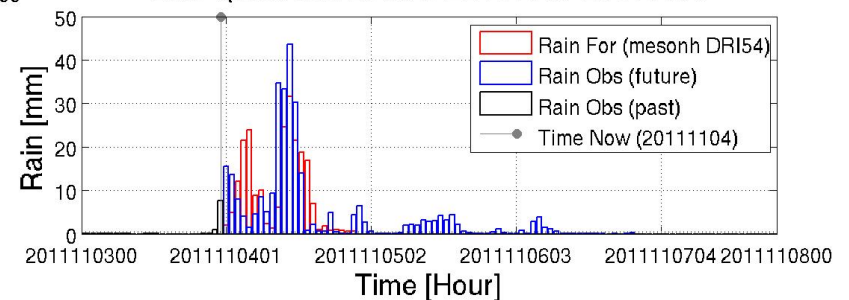
DRiFt(arome D06D 6: 20111103-20111108)



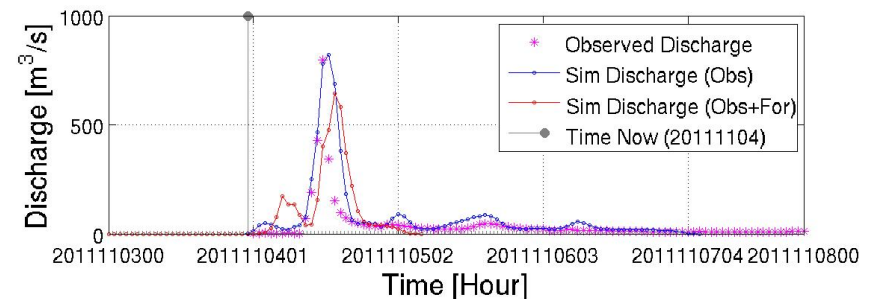
DRiFt driven by **Arome**
ensemble member #6

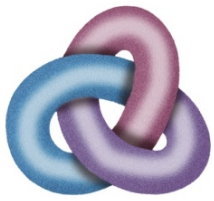


DRiFt(mesonh DRI54: 20111103-20111108)



DRiFt driven by **Meso-NH**
ensemble member DRI54

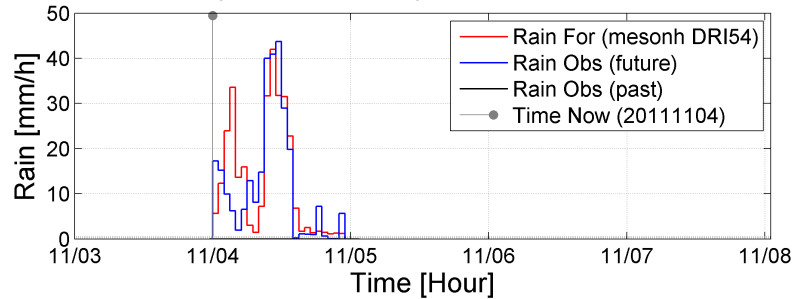




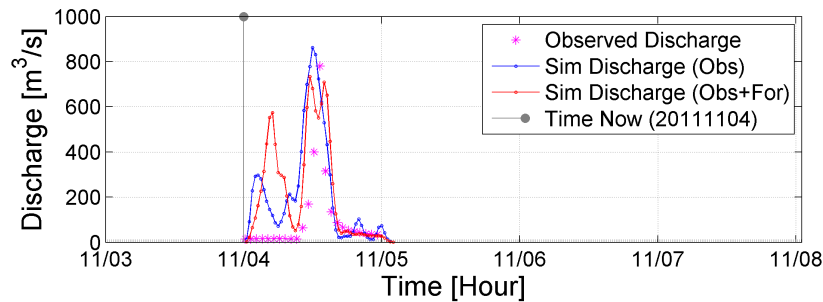
Comparison of different models



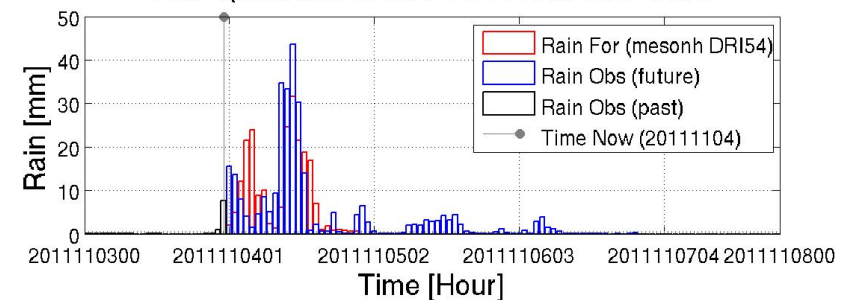
RIBS(mesonh DRI54): 20111104-20111105



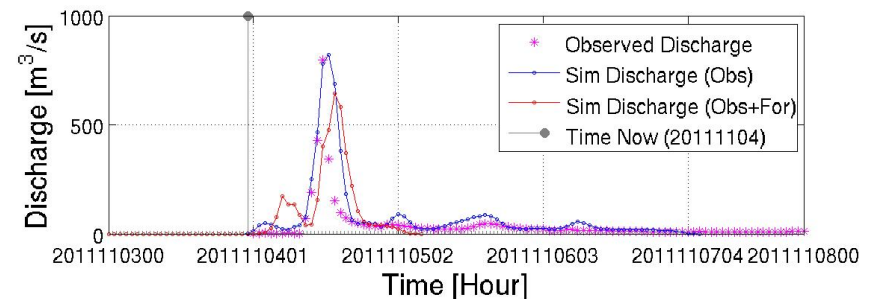
RIBS driven by **Meso-NH**
ensemble member DRI54

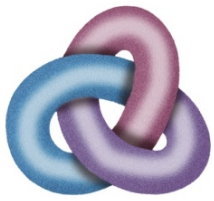


DRiFt(mesonh DRI54: 20111103-20111108

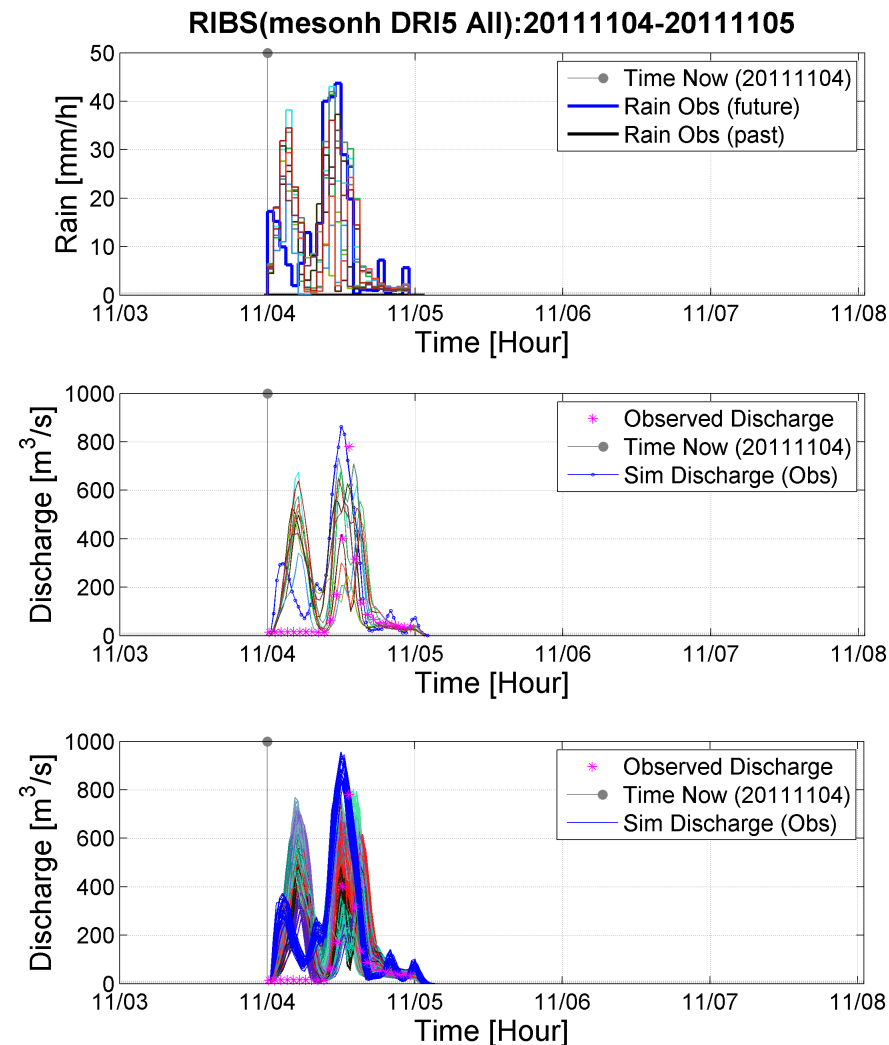


DRiFt driven by **Meso-NH**
ensemble member DRI54





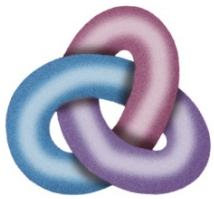
Combination of meteorological and hydrological ensembles



Rainfall from **observations** and
Meso-NH ensemble
DRI5X

Deterministic RIBS driven by
Meso-NH ensemble DRI5X

RIBS ensemble driven by
Meso-NH ensemble DRI5X

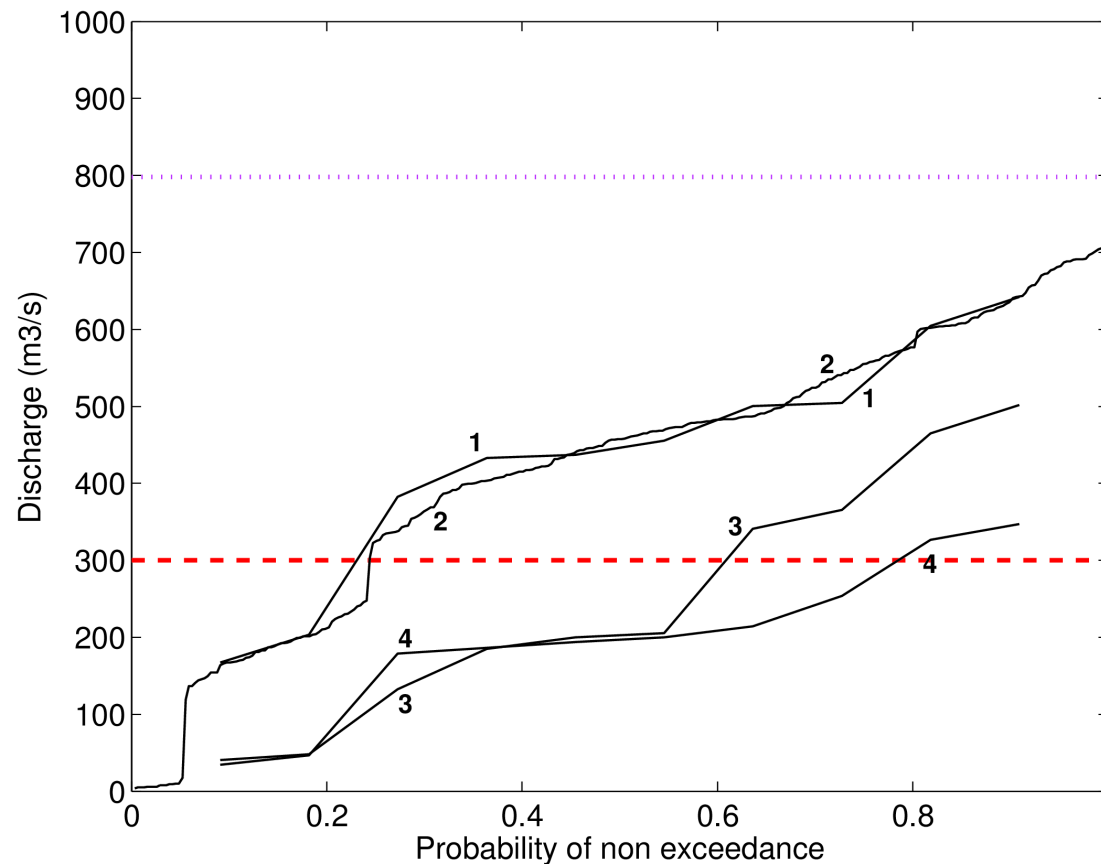


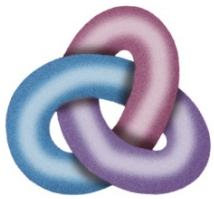
Evaluation of probabilistic hydrometeorological chains

Sensitivity to hydrological model

Meso-NH ensemble DRI5X driving:

- 1: **Deterministic RIBS**
- 2: **RIBS ensemble**
- 3: **Deterministic DRiFt**
- 4: **Deterministic HBV**





Evaluation of probabilistic hydrometeorological chains

Sensitivity to meteorological model

Deterministic RIBS driven by:

1: **observed rainfall**

2: **AROME**

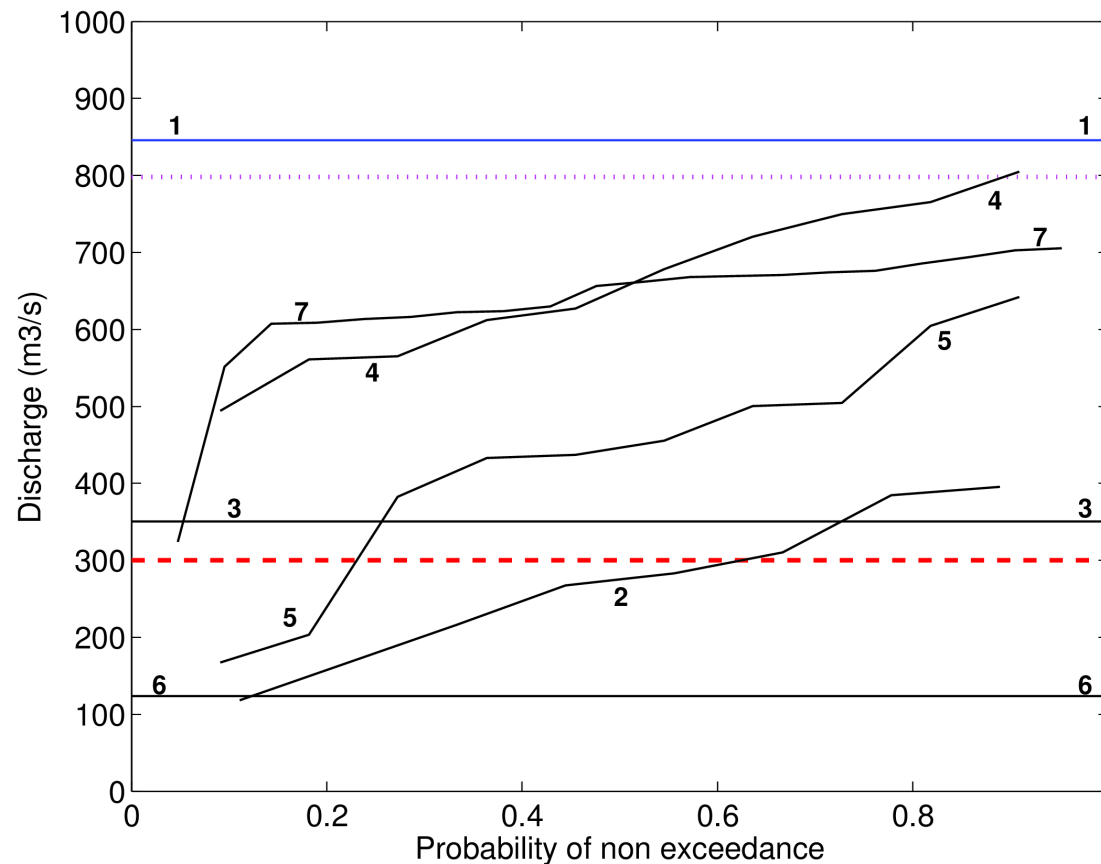
3: **WRF-ARW**

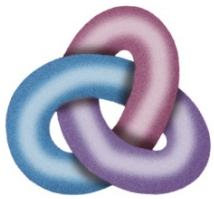
4: **Meso-NH ensemble DRI5X**

5: **Meso-NH ensemble DRI6X**

6: **WRF-NMM**

7: **RainFARM**





Summary of benefits

Technical benefits:

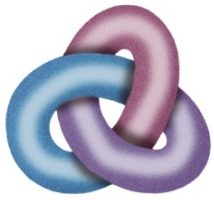
- *Production of large multi-model ensemble hydrometeorological forecasts*
- *Comparisons between different models/ensembles*
- *Combinations between different models/ensembles*
- *Sensitivity studies to individual components of the hydrometeorological chain*

Scientific benefits:

- *Process studies (predictability, identification of key processes)*
- *Evaluation of respective performance of each of the models/ensembles*
- *Guidance for the design of operational hydrometeorological forecasting chains*

Further reading:

- Hally, A., Caumont, O., Garrote, L., Richard, E., Weerts, A., Delogu, F., Fiori, E., Rebora, N., Parodi, A., Mihalović, A., Ivković, M., Dekić, L., van Verseveld, W., Nuissier, O., Ducrocq, V., D'Agostino, D., Galizia, A., Danovaro, E., and Clematis, A.: Hydrometeorological multi-model ensemble simulations of the 4 November 2011 flash-flood event in Genoa, Italy, in the framework of the DRIHM project, *Nat. Hazards Earth Syst. Sci. Discuss.*, 2, 6653-6701, doi:10.5194/nhessd-2-6653-2014, 2014.

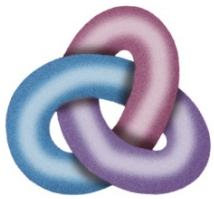


The Genoa 2011 Case

The Set of Models

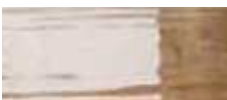
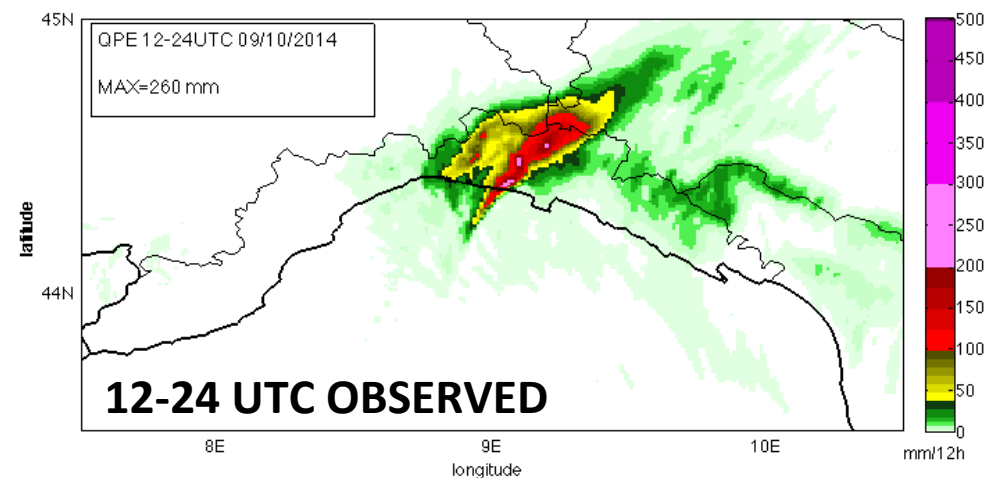
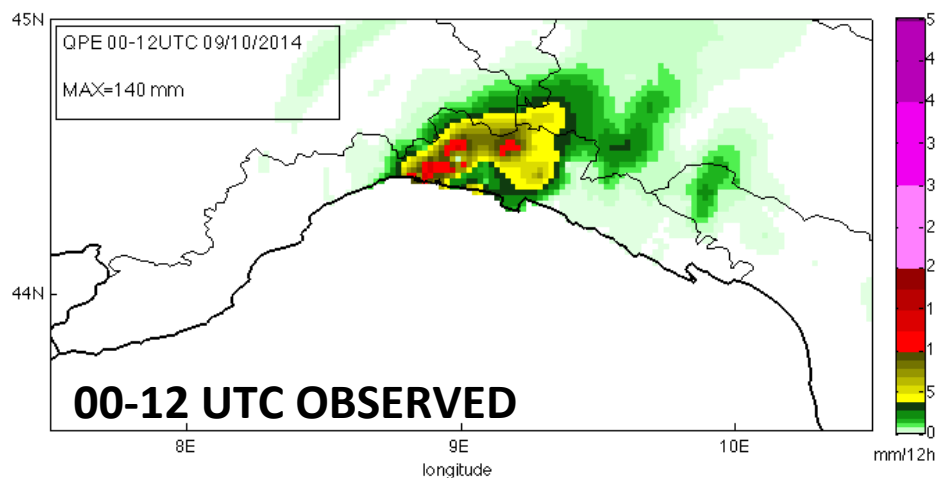
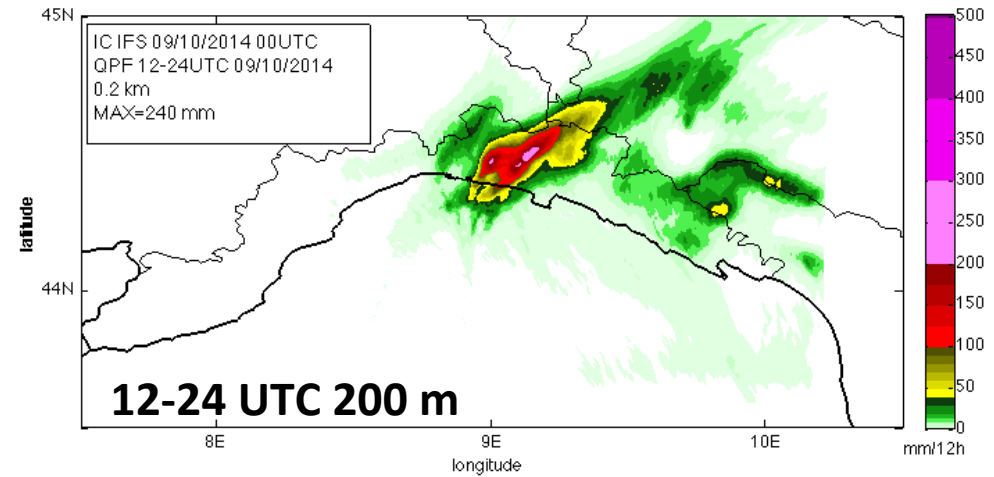
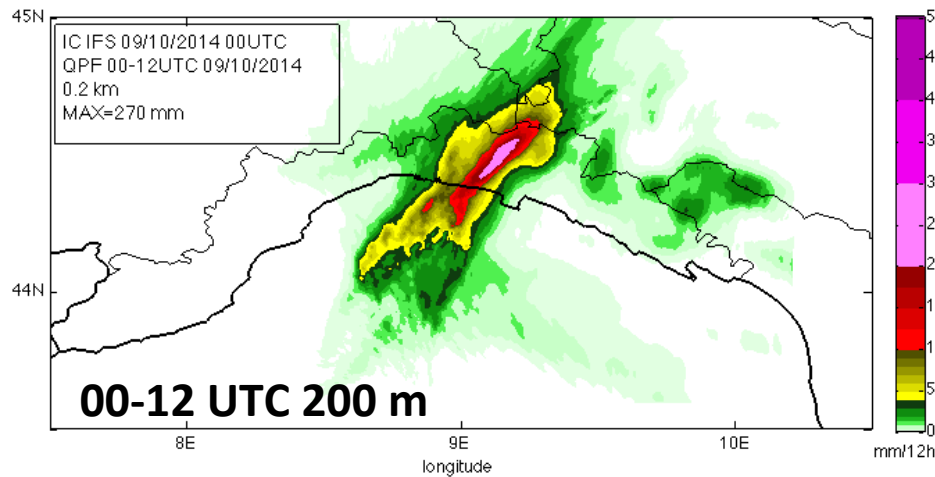
Benefits Gained from DRIHM e-Science Infrastructure

➔ Initial Results on the
Genoa 2014 Case

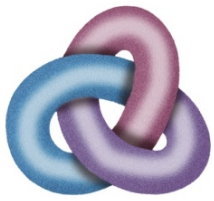


WRF-ARW @ 200 m (IFS)

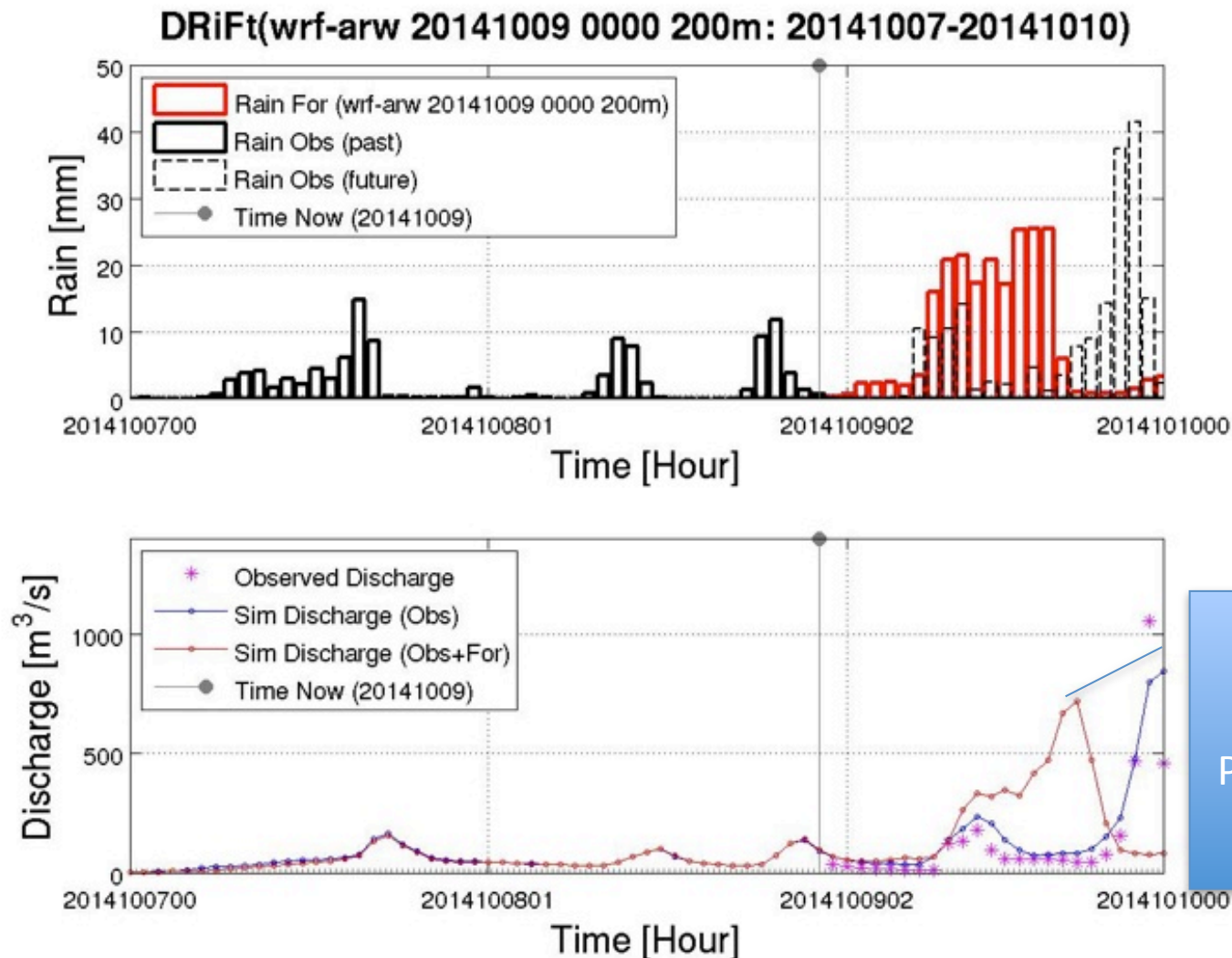
Quantitative precipitation forecasts



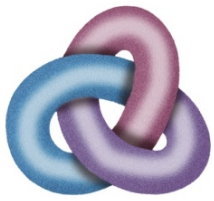
Initialization at 00 UTC, 09 Oct. 2014 – 3 nested domains



DRiFt driven by WRF-ARW @ 200 m (IFS)

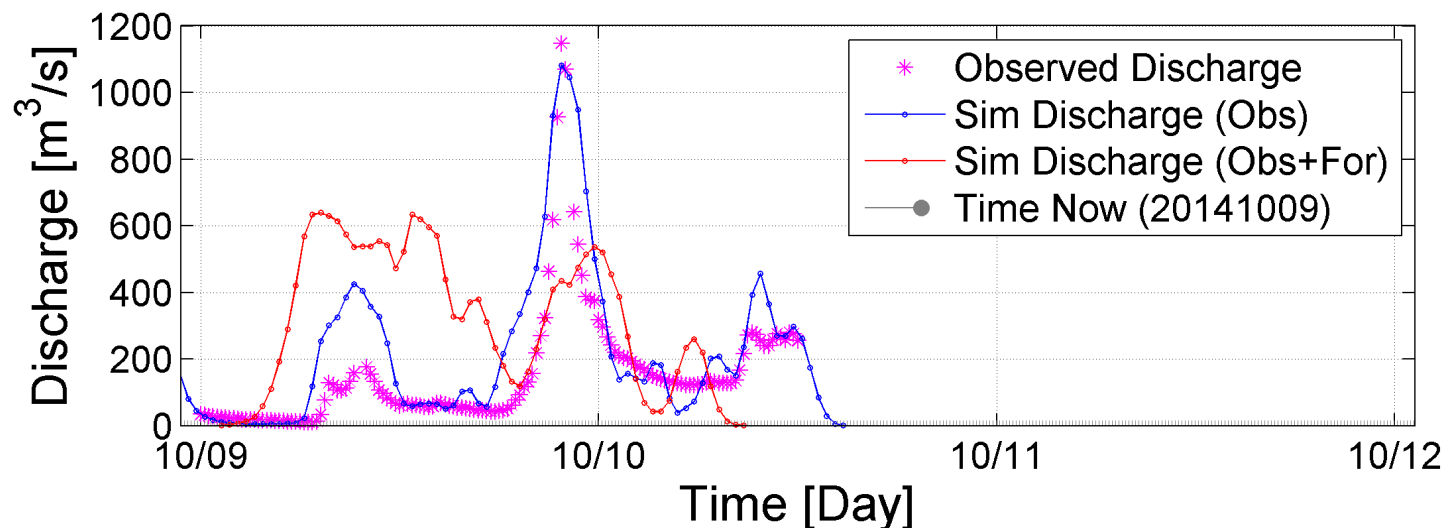
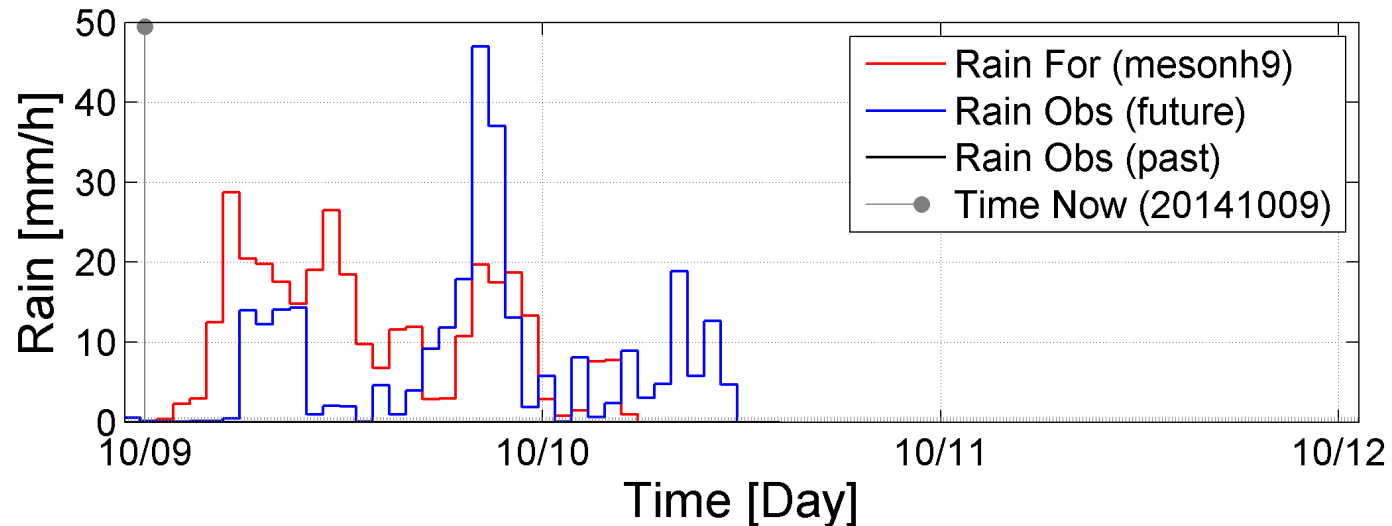


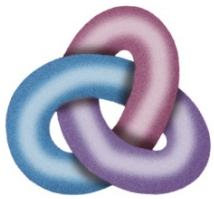
Run 9/10
00UTC 200 m
Peak: 650 m^3/s
at 18 UTC



RIBS driven by Meso-NH ensemble @ 500 m (IFS)

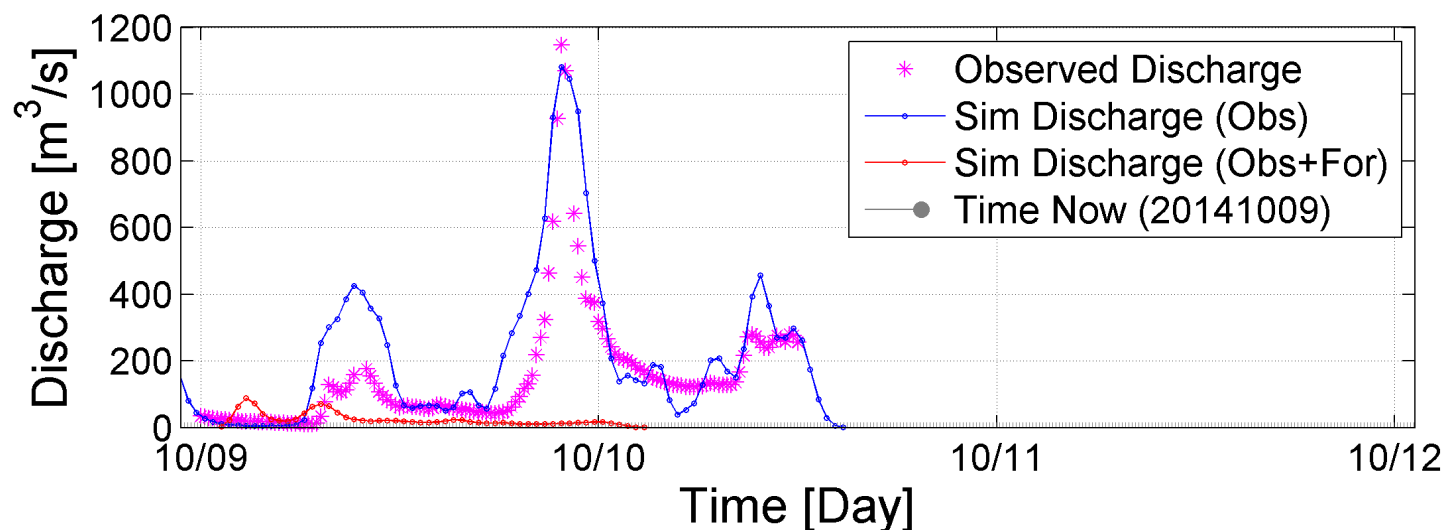
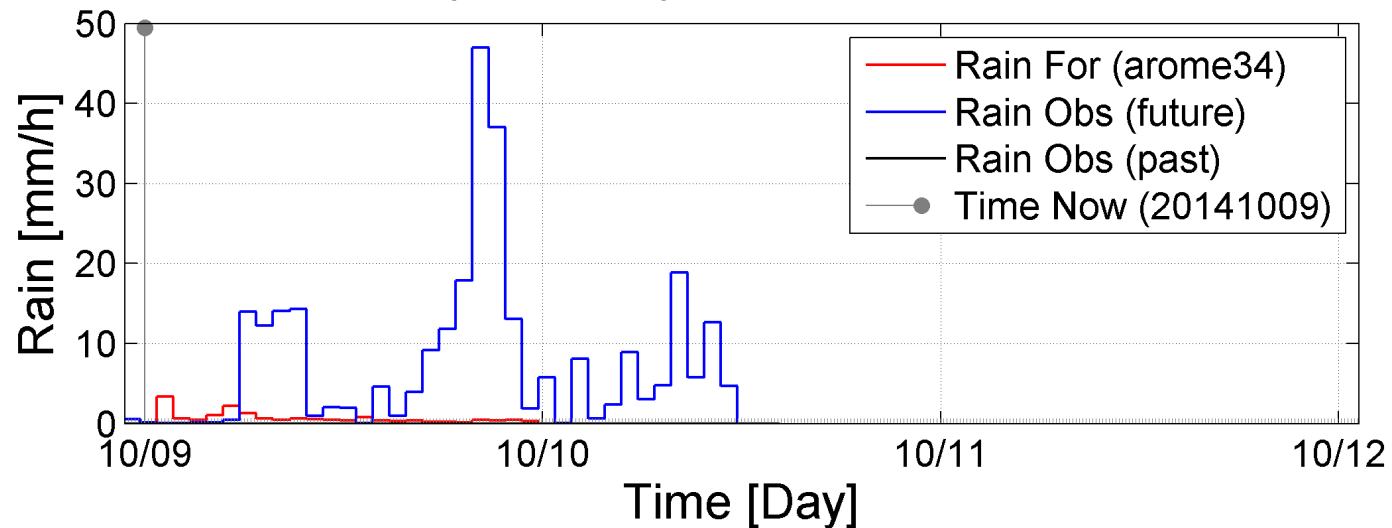
RIBS(mesonh9): 20141009-20141011

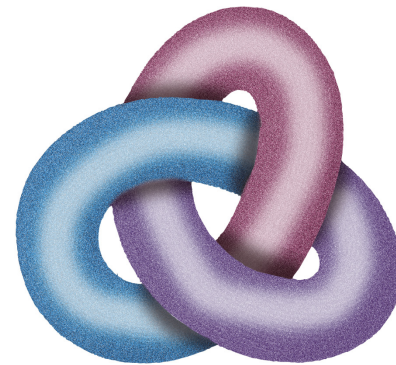
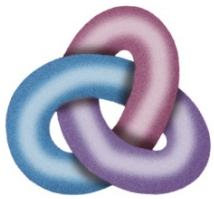




RIBS driven by Arome ensemble @ 2.5 km (PEARP)

RIBS(arome34): 20141009-20141011





DRIHM

DISTRIBUTED RESEARCH INFRASTRUCTURE
FOR HYDRO-METEOROLOGY



e-infrastructure

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under the 7th Framework Programme*



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