1st European Fully Coupled Atmospheric-Hydrological Modeling and WRF-Hydro Users workshop

University Club Hall at University of Calabria (Cosenza - Italy), June 11-13, 2014

Fully coupled WRF-Hydro atmospheric-hydrological modeling in a Mediterranean catchment

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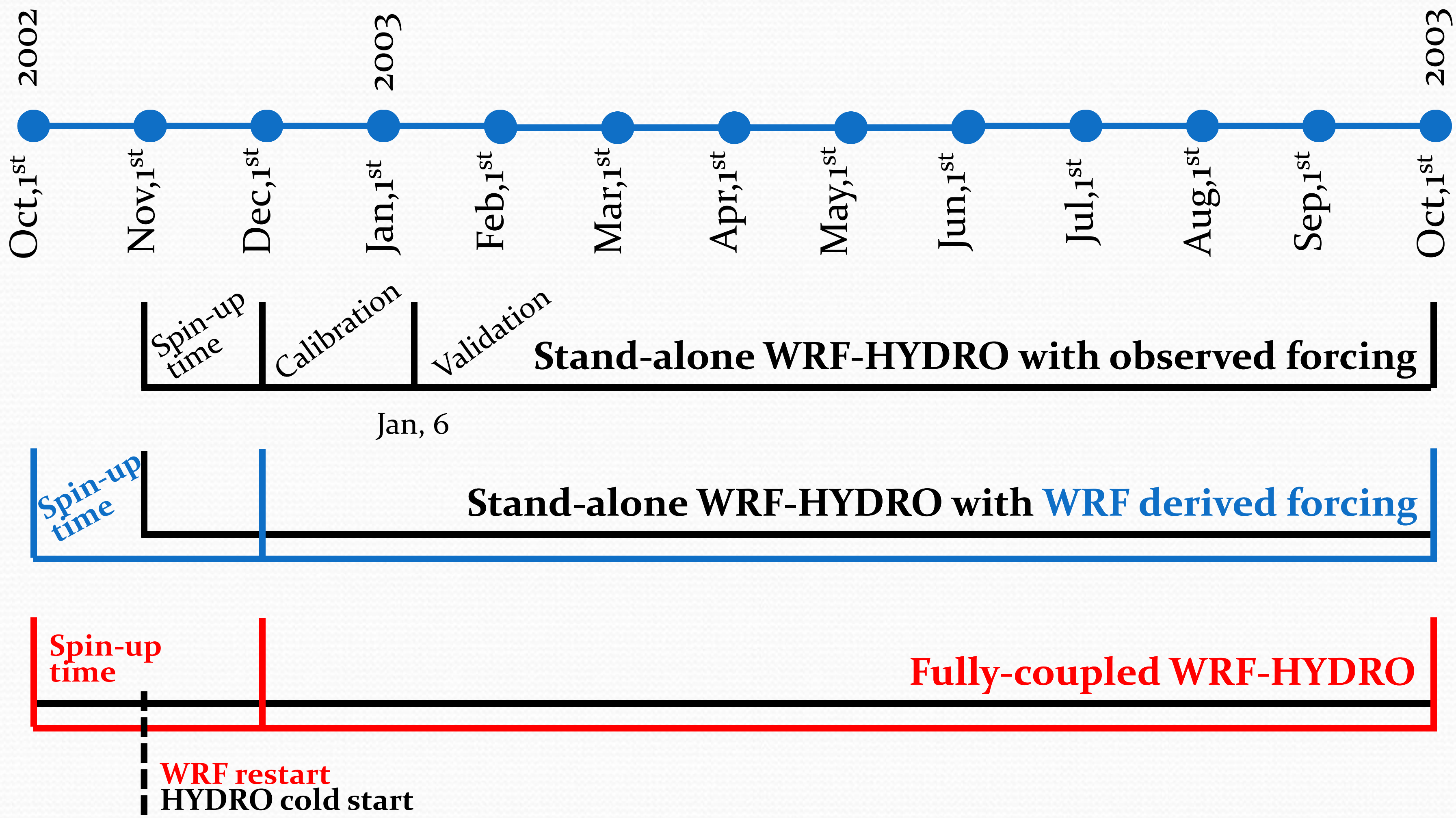
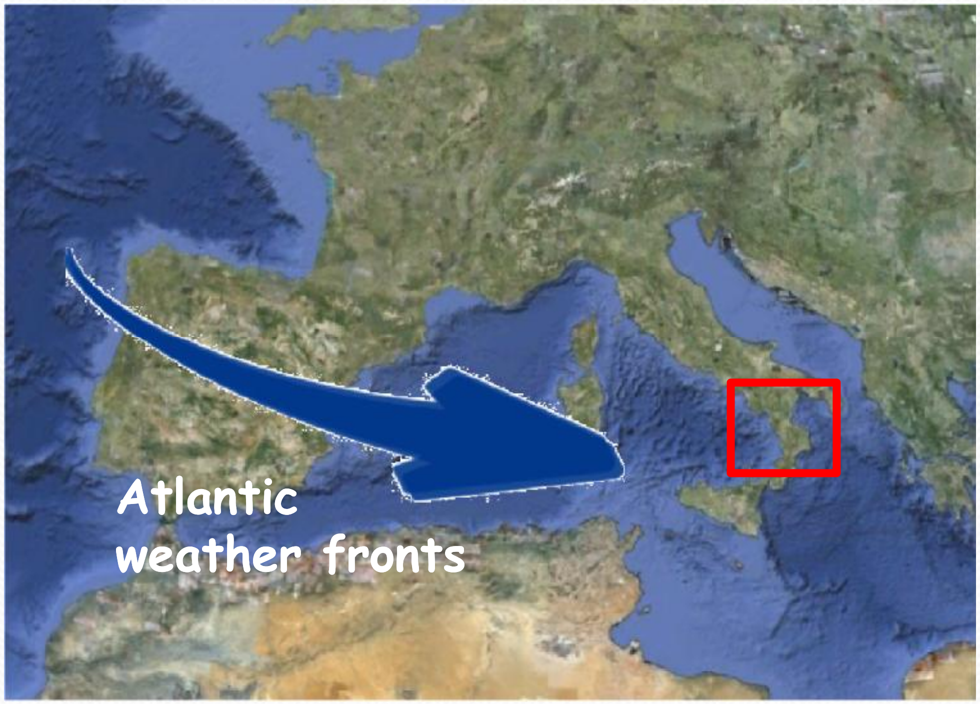
Objectives

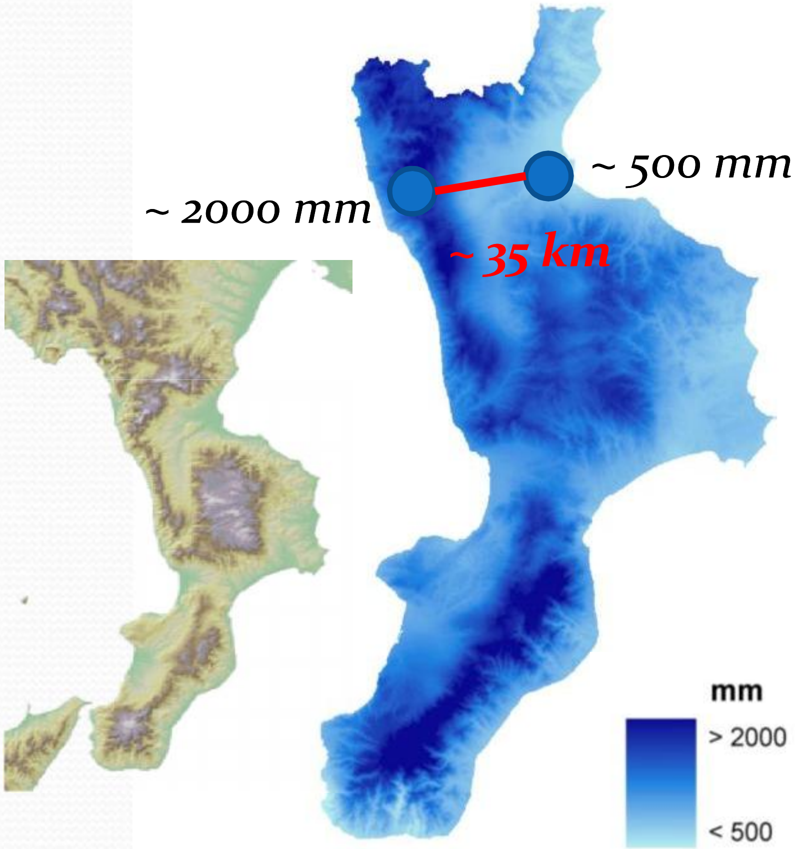
- Reliability of stand-alone WRF-Hydro hydrological model in a Mediterranean catchment (comparison of observed and simulated **streamflow**)
- Parameterization and evaluation of stand-alone WRF mesoscale model, with particular reference to **precipitation**
- Comparison of both **stand-alone** models and **one-way coupled** modeling system to **fully coupled** WRF-Hydro modeling system
- Evaluating potential of fully coupled modeling, both for **hydrometeorological forecasts** (short-medium range) and **hydrological impacts due to climate change** (long-range)

Methodology

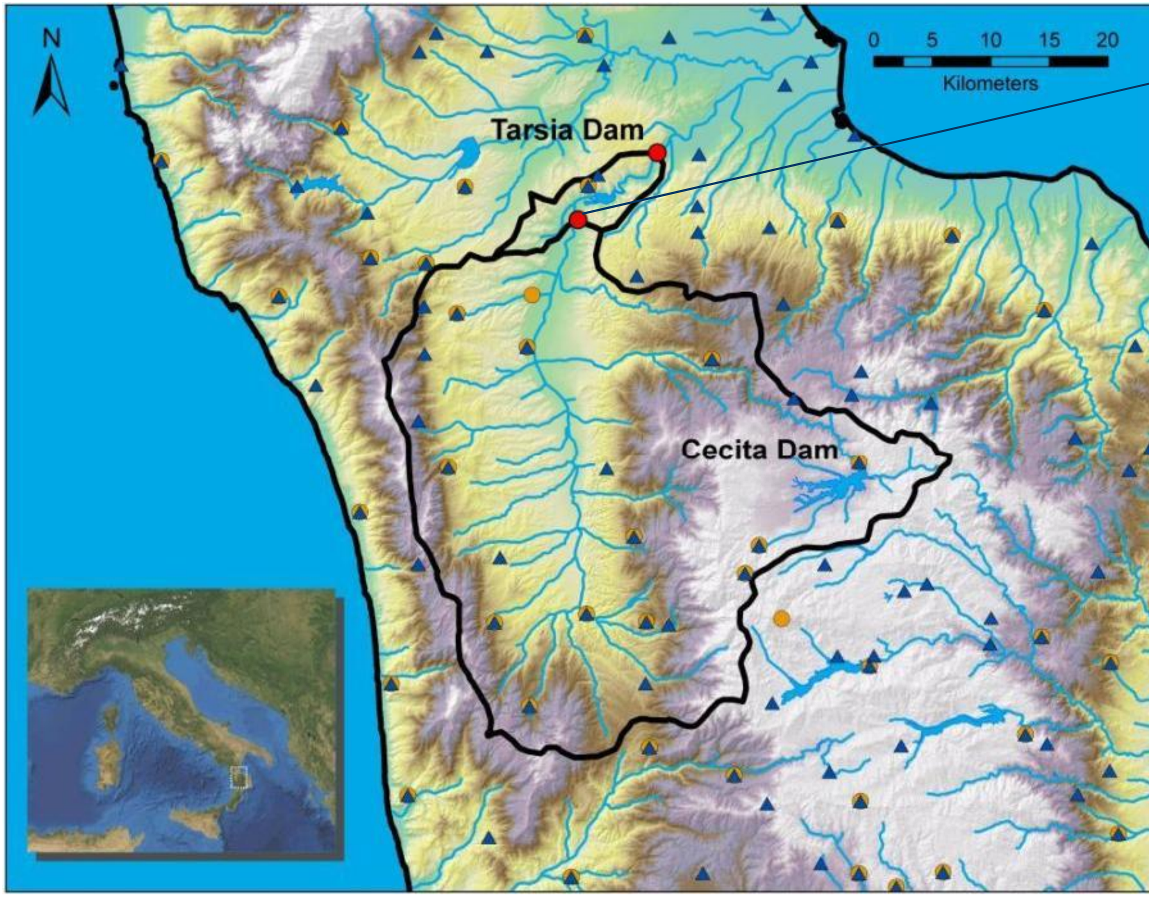


Study area





Study area (stand-alone WRF-Hydro)



"Crati @ S. Sofia" gauging station
1281 km²
250 m horizontal resolution

H_{max} = 1856 m
H_{mean} = 672 m
H_{min} = 49 m

mean precipitation **1200 mm**
mean temperature **11.9 °C**

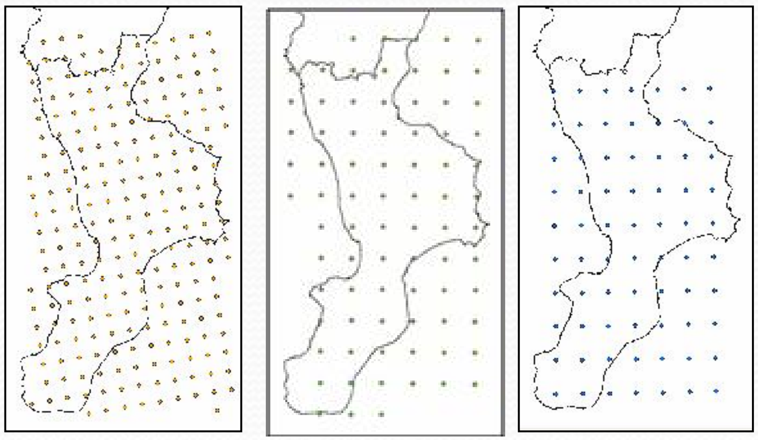
45 rain gauges ▲	(10)
35 thermometers ●	(11)
11 radiometers	(3)
12 hygrometers	(5)
8 anemometers	(2)
6 barometers	(2)

Longwave radiation → GLDAS

Study area

2070–2099 vs. 1961–1990

- Previous studies: one-way coupling with RCMs



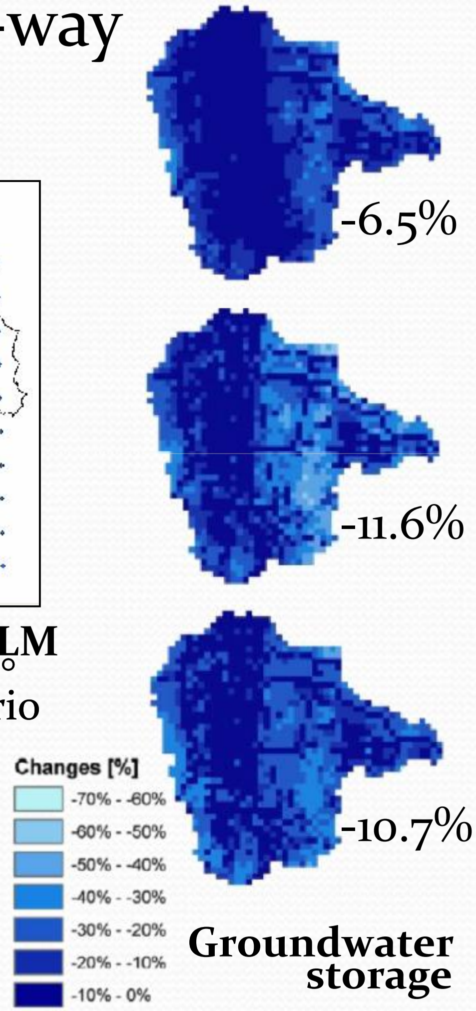
HIRHAM
res. 0.11°
A2 scenario

RegCM
res. 20 km
A2 scenario

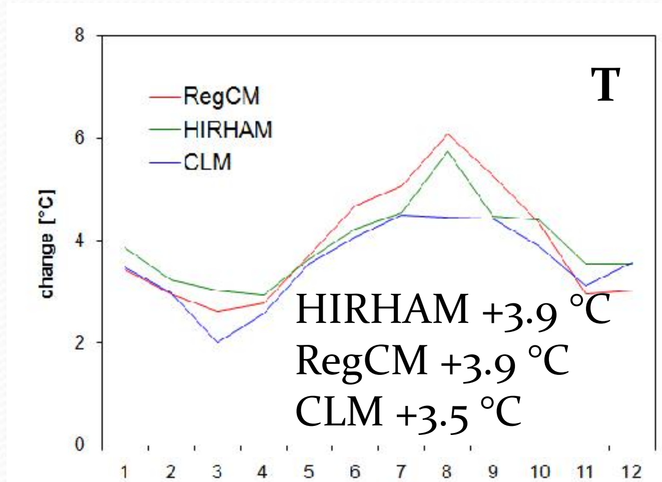
COSMO-CLM
res. 0.165°
A1B scenario

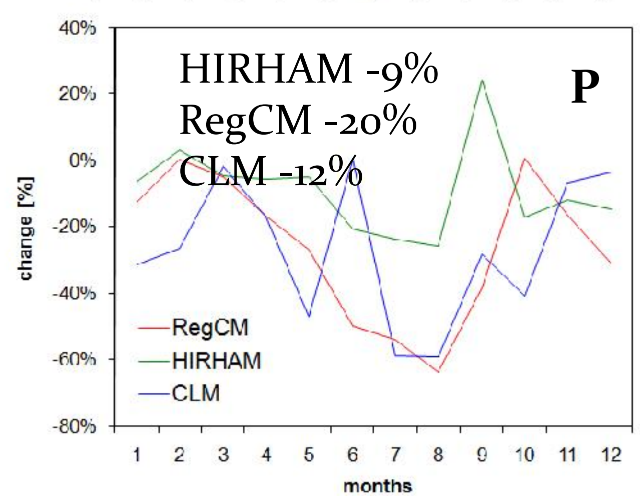
In-STRHyM hydrological model
1 km res.
daily time step

Senatore et al., JoH, 2011

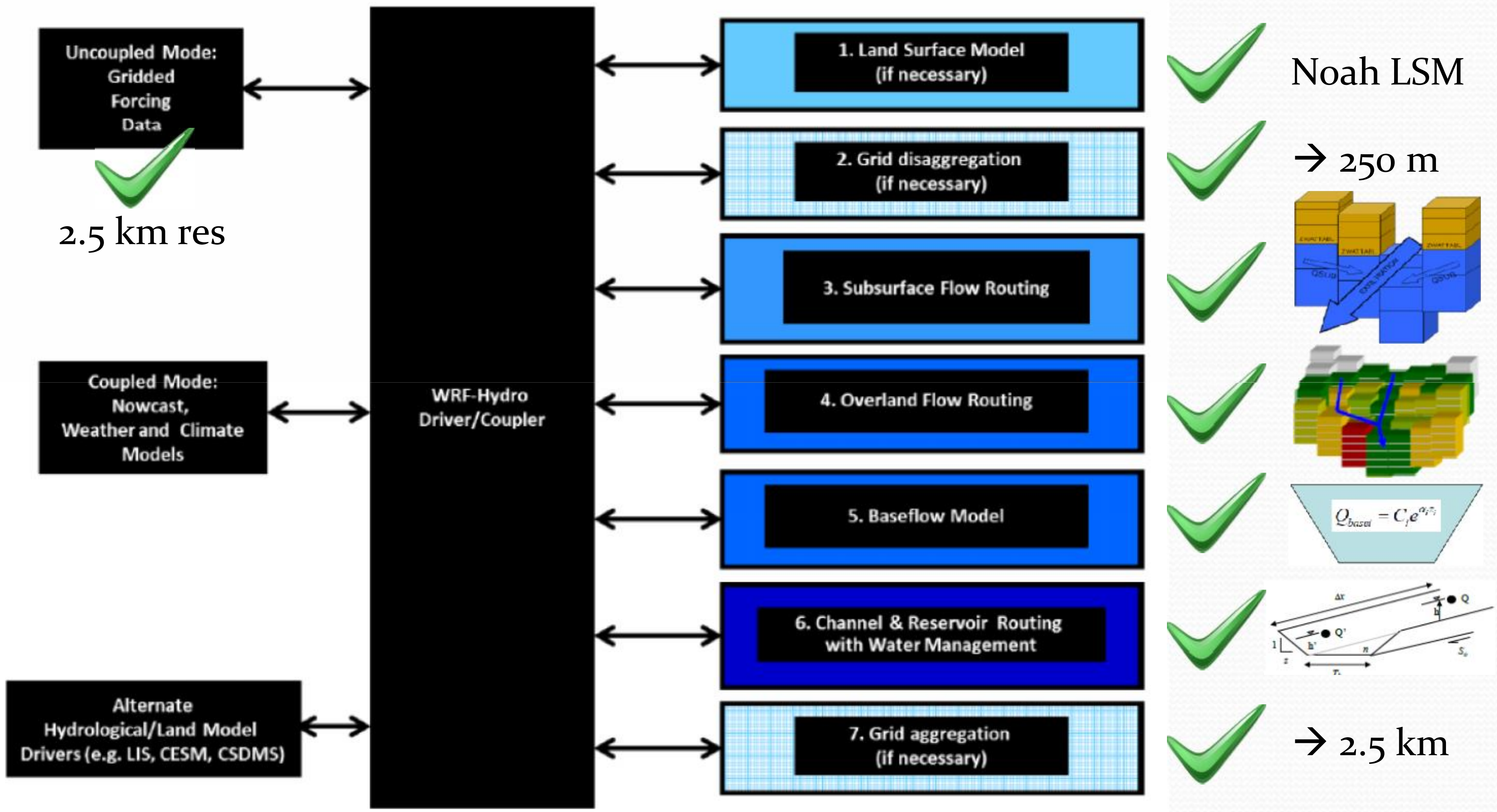


Groundwater storage





Stand-alone WRF-Hydro



Stand-alone WRF-Hydro

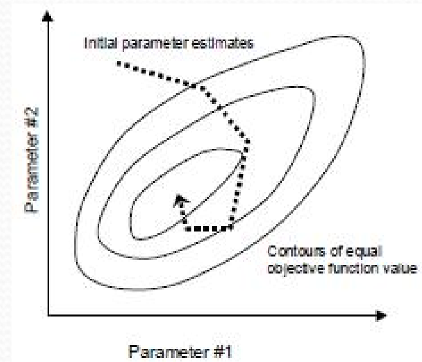
- Calibration procedure

PEST

Model-Independent Parameter Estimation & Uncertainty Analysis

www.pesthomepage.org

Minimization of the objective function F, given by the sum of squared deviations between model-generated observations and experimental observations , by means of the Gauss-Marquardt-Levenberg method (non-linear estimation technique)



- Experimental observations? Hourly streamflow

Stand-alone WRF-Hydro

- Parameters involved in the calibration process

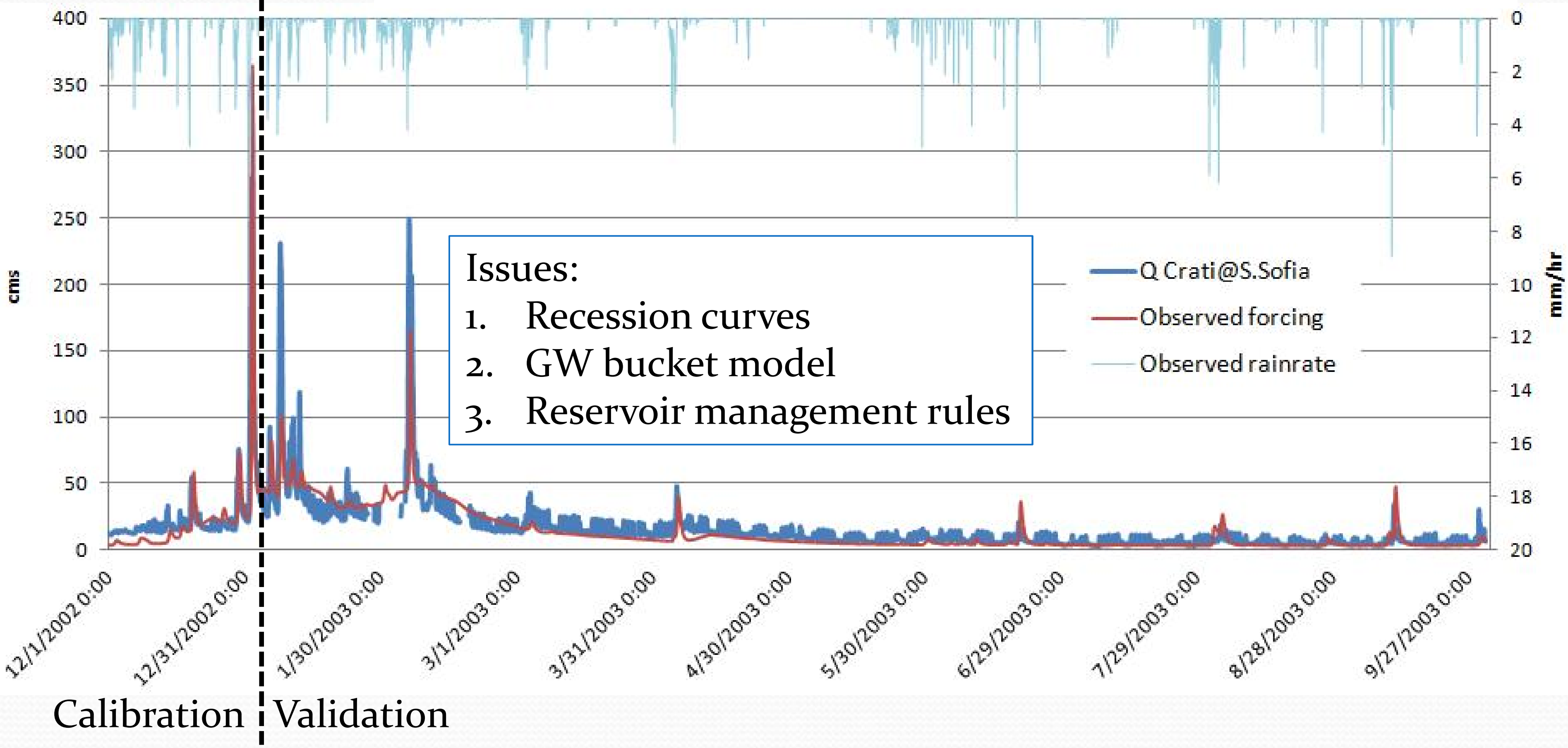
Several (dozens!) preliminary simulations in order to understand sensitivity of the model to single parameters

- 4 Manning roughness coefficients (CHANPARM.TBL)
- Bucket model exponent (GWBUCKPARM.TBL)
- Slope coefficient modifying the drainage out the bottom of the last soil layer (GENPARM.TBL)
- Noah surface runoff parameter refkdt (GENPARM.TBL)
- Accompanying parameter refdk (corresponding to K_{sat} for silty clay loam) (GENPARM.TBL – SOILPARM.TBL)
- K_{sat} for sandy loam (most diffused texture in the basin) (SOILPARM.TBL)
- depth of the bottom of the first soil layer (namelist.hrldas, hydro.namelist)
- gridded values of the overland flow roughness scaling factor (OVROUGHRTFAC)

Stand-alone WRF-Hydro

- Calibration results

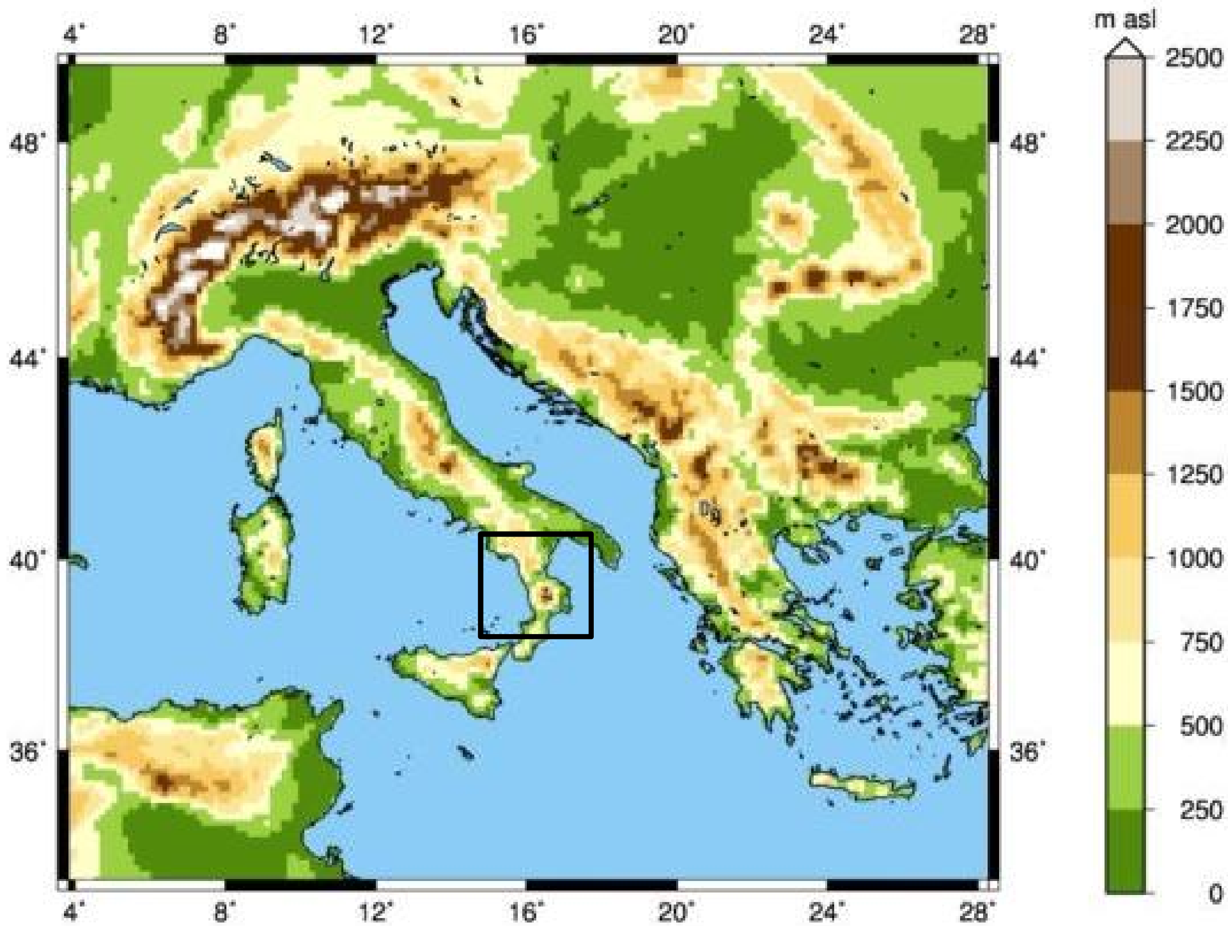
Calibration N.S. = 0.93 Validation N.S. = 0.72 Overall N.S. = 0.80

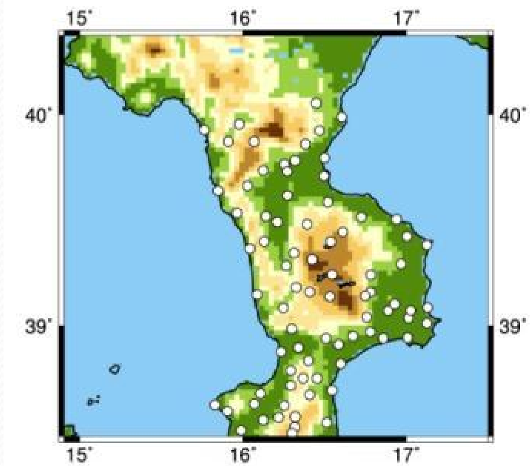


Issues:

1. Recession curves
2. GW bucket model
3. Reservoir management rules

Study area (WRF, WRF-Hydro)





Small domain
2.5 km hor. res.
(95 x 90 grid points)

One-way nesting

Large domain
12.5 km hor. res.
(172 x 154 grid points)

WRF parameterization

- WRF configurations

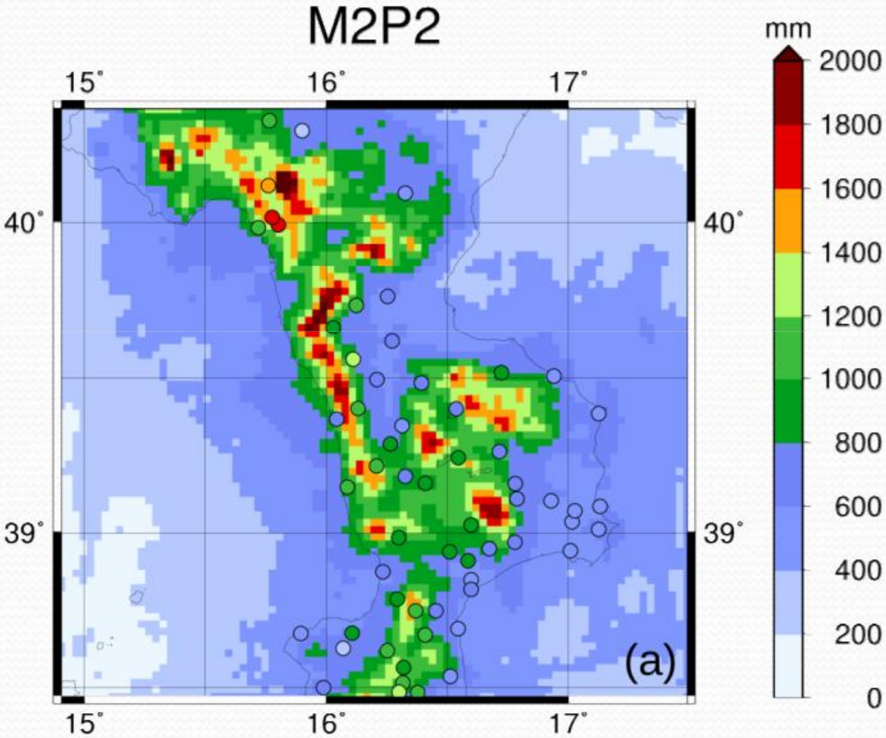
Acronyms	M2P1	M2P2	M6P1	M6P2	M8P1	M8P2	M2P2C3	M6P2C3
Microphysics	2	2	6	6	8	8	2	6
PBL	1	2	1	2	1	2	2	2
Cum. param.	1	1	1	1	1	1	3	3

- Microphysics: **2** - Purdue Lin; **6** - WSM6; **8** - Thompson graupel
- PBL: **1** - YSU scheme; **2** – MYJ
- Cumulus parameterization: **1** - Kain-Fritsch; **3** - Grell-Devenyi ensemble
- Rapid Radiative Transfer Model (RRTM) for longwave radiation
- Dudhia scheme for shortwave radiation
- Unified Noah Land-Surface Model

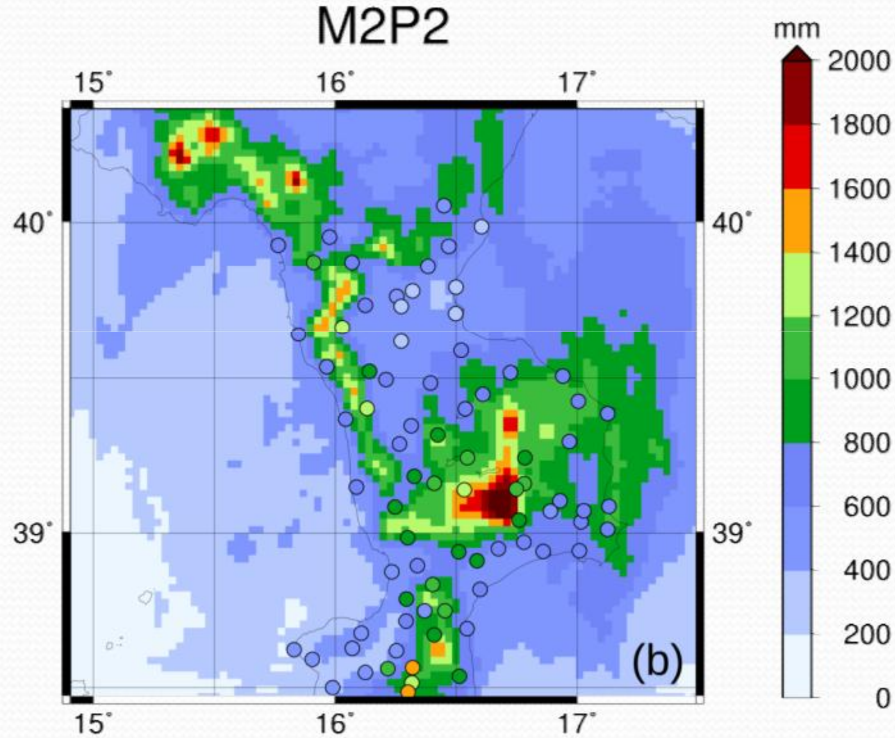
Senatore et al., JoHM, minor review

WRF parameterization

- Maps of simulated precipitation fields



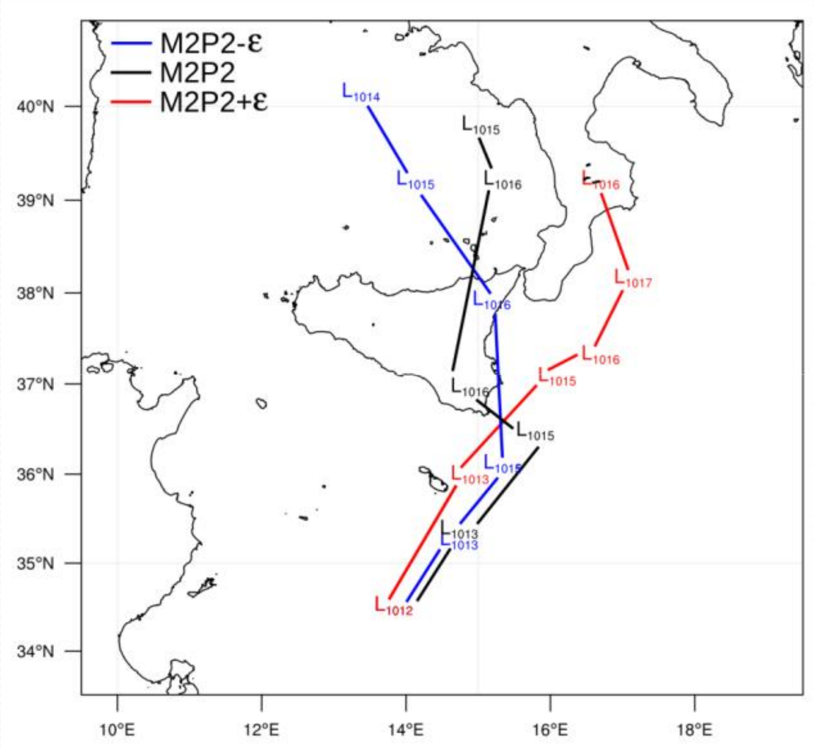
Dry period



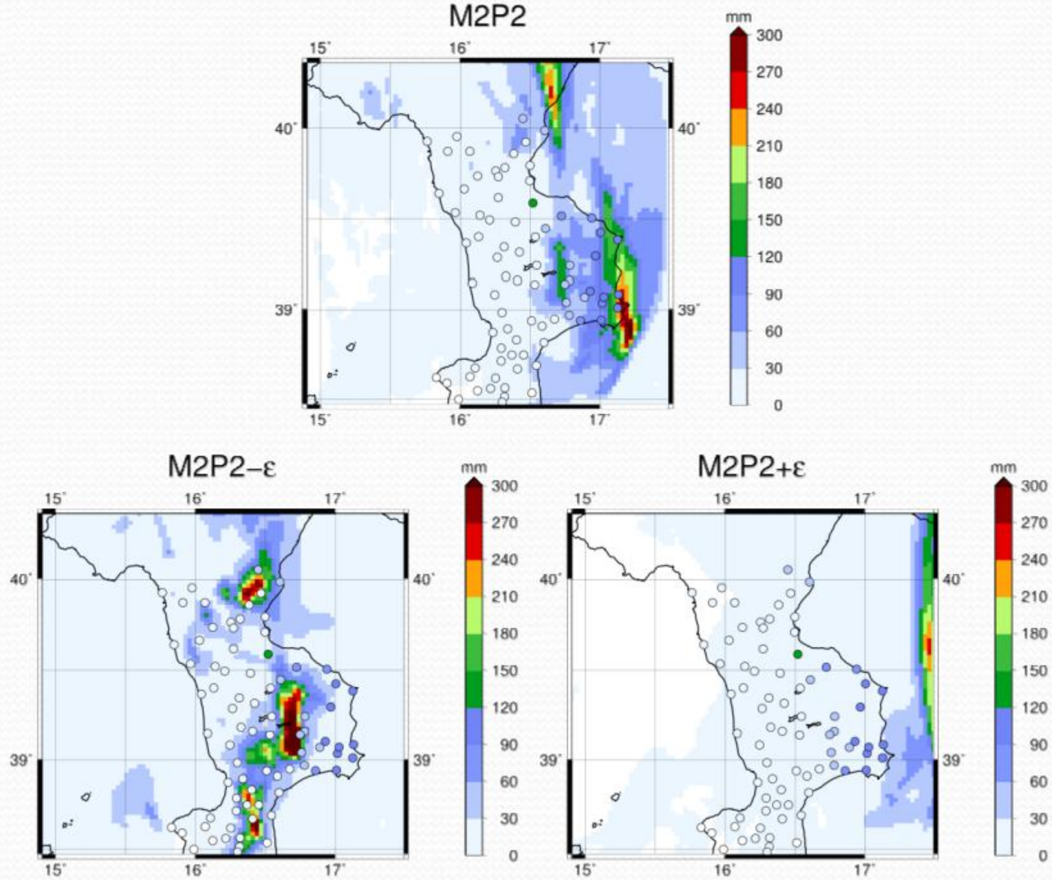
Wet period

WRF parameterization

- Sensitivity to SST



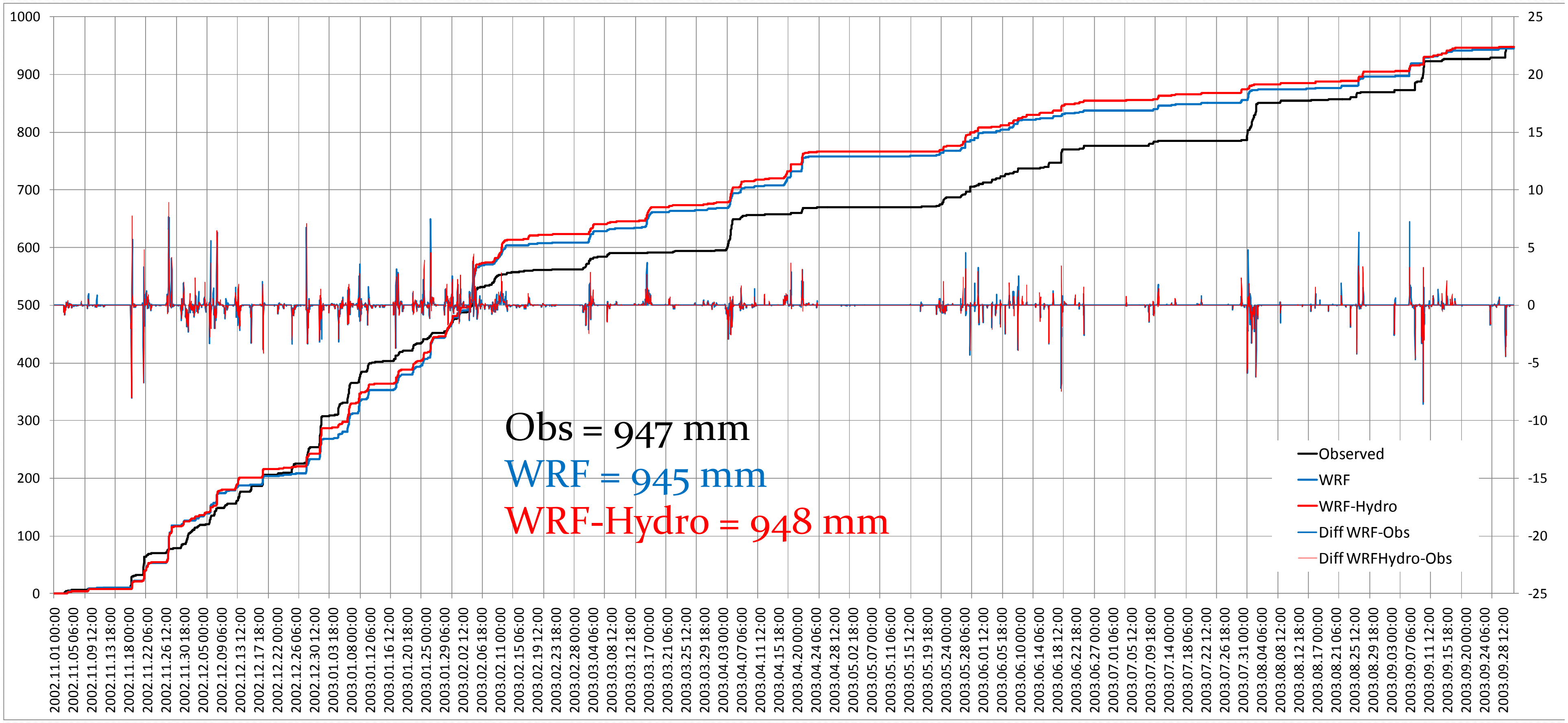
Tracks of pressure minima



Daily precipitation patterns

Results

- Averaged precipitation evolution in the catchment



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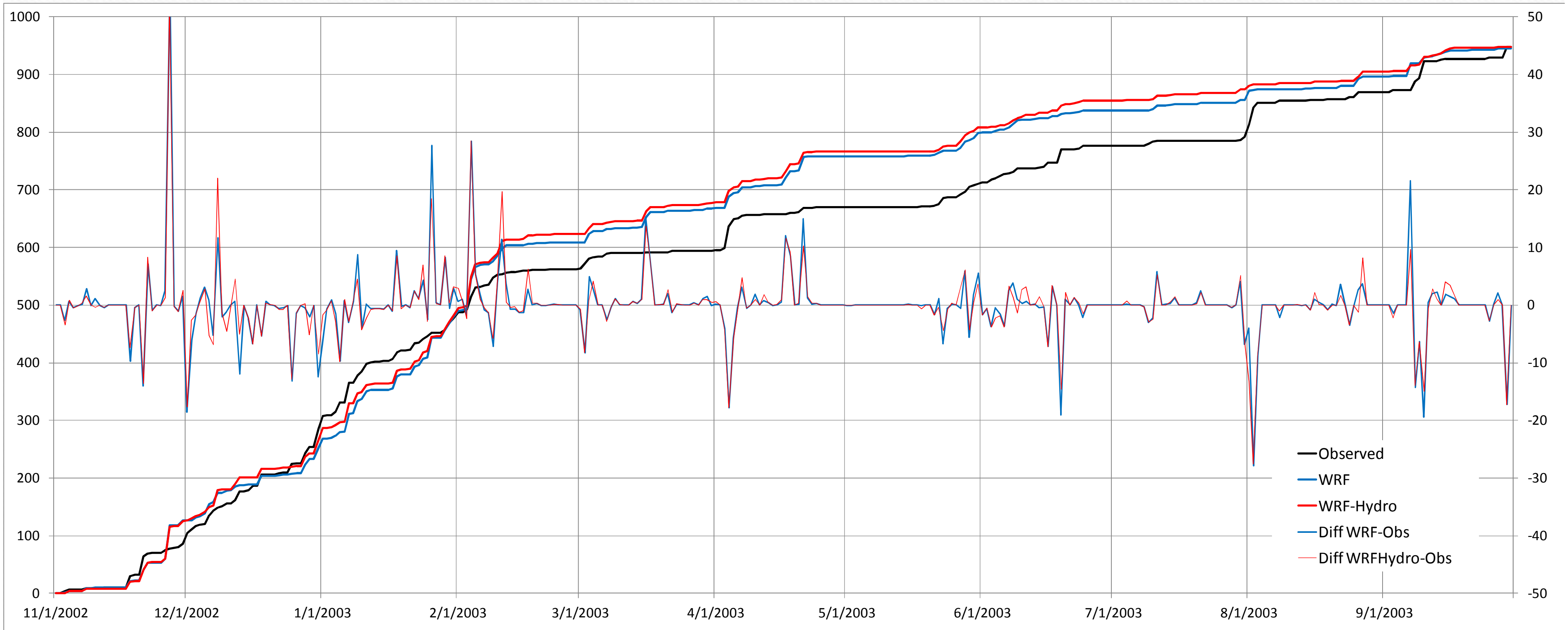
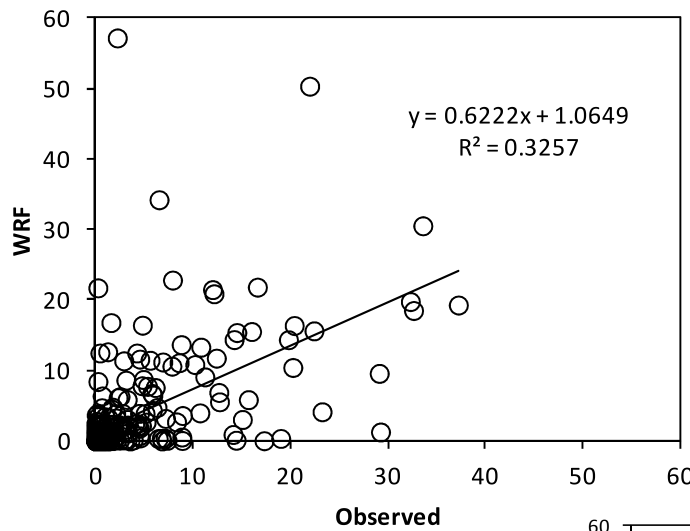
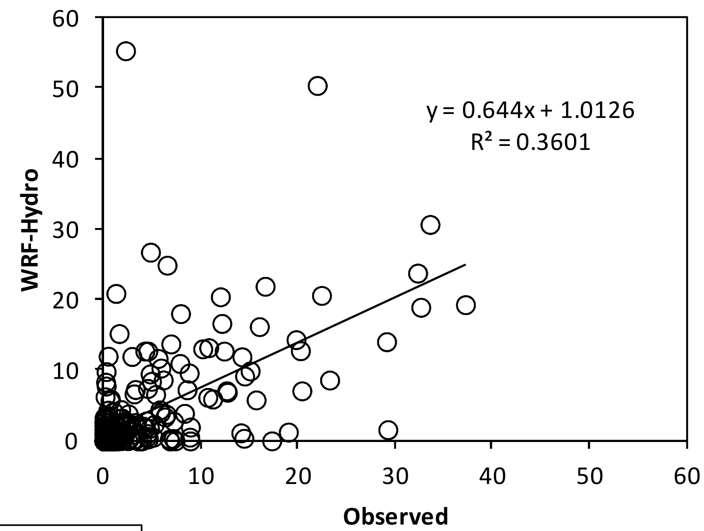
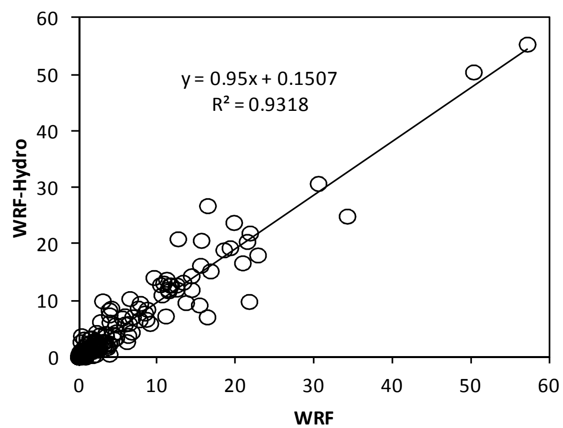


Results

- Averaged daily precipitation in the catchment

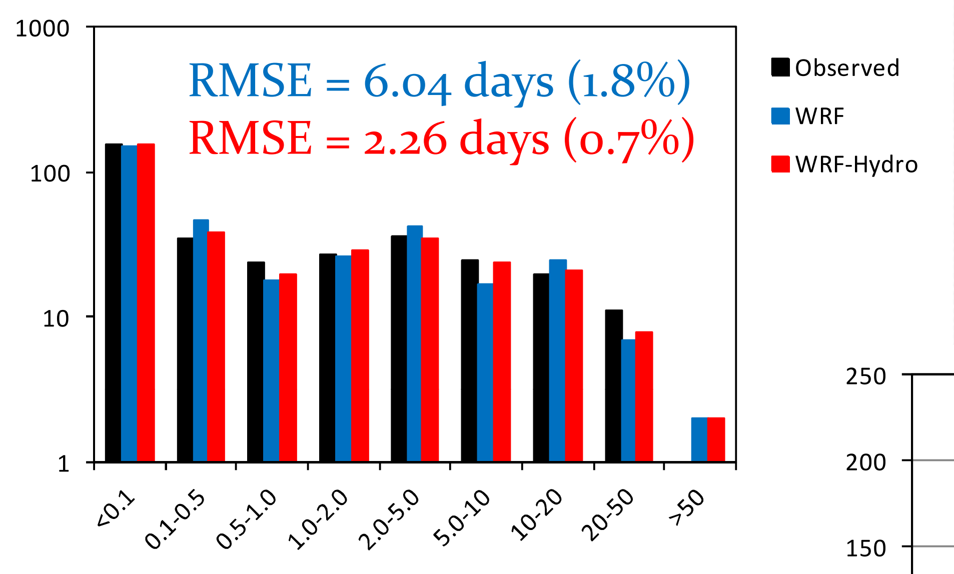


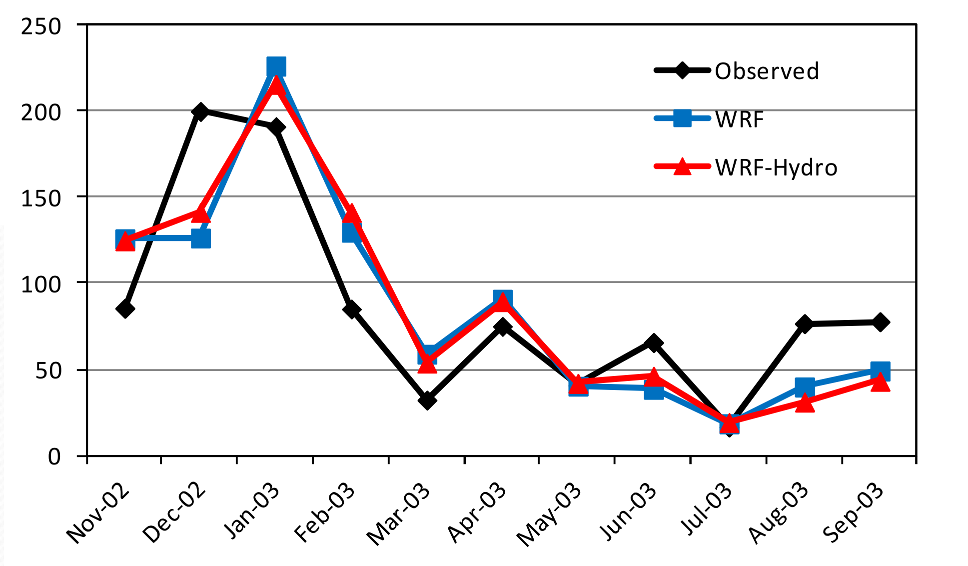




Results

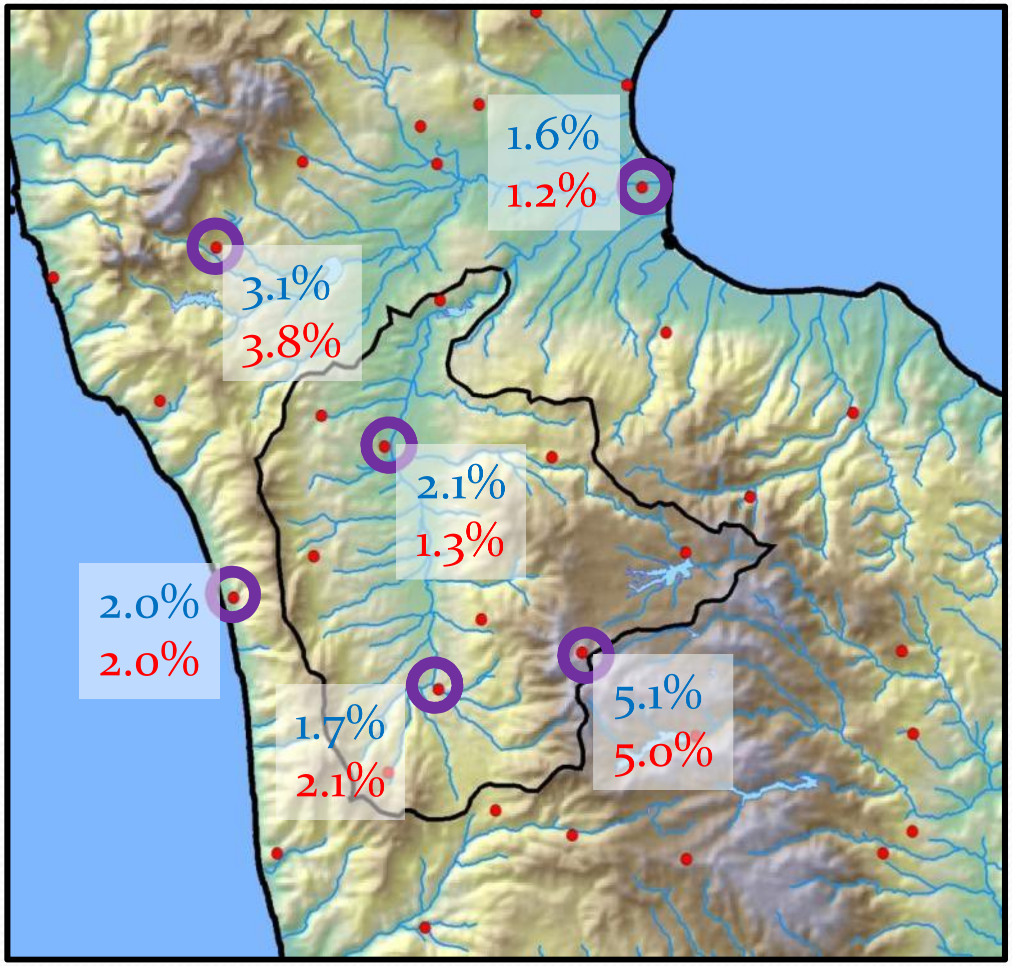
- Averaged precipitation in the catchment

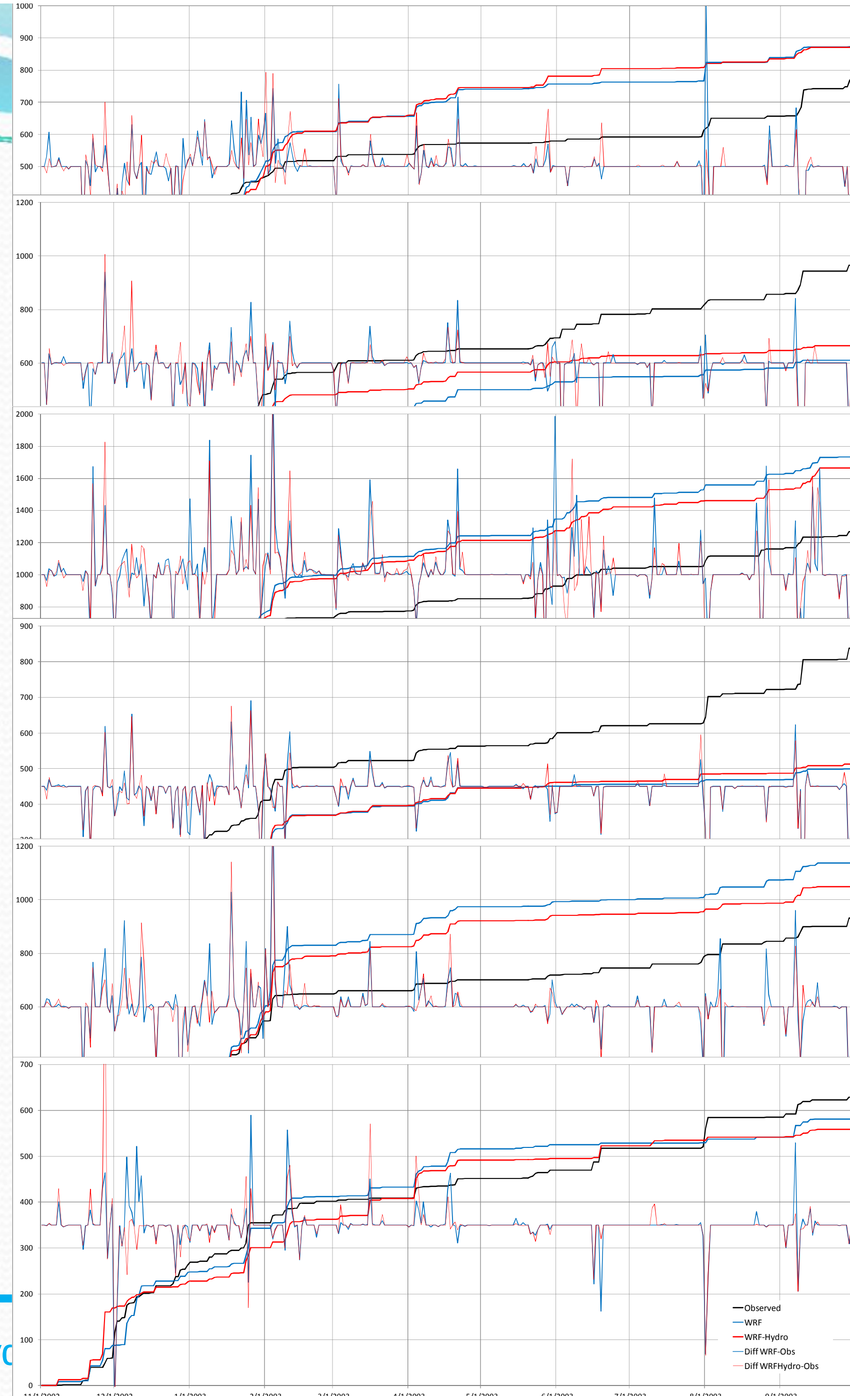




Results

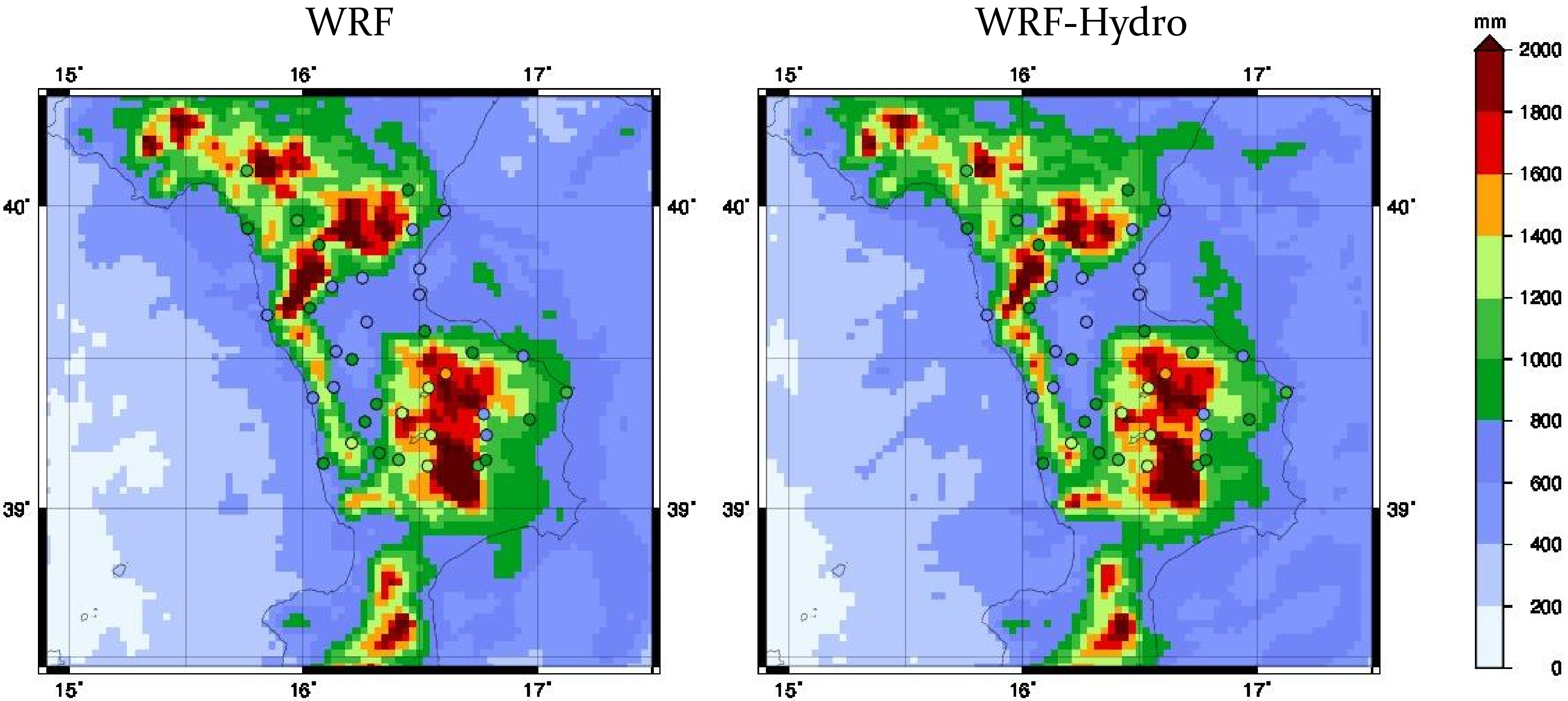
- Averaged precipitation





Results

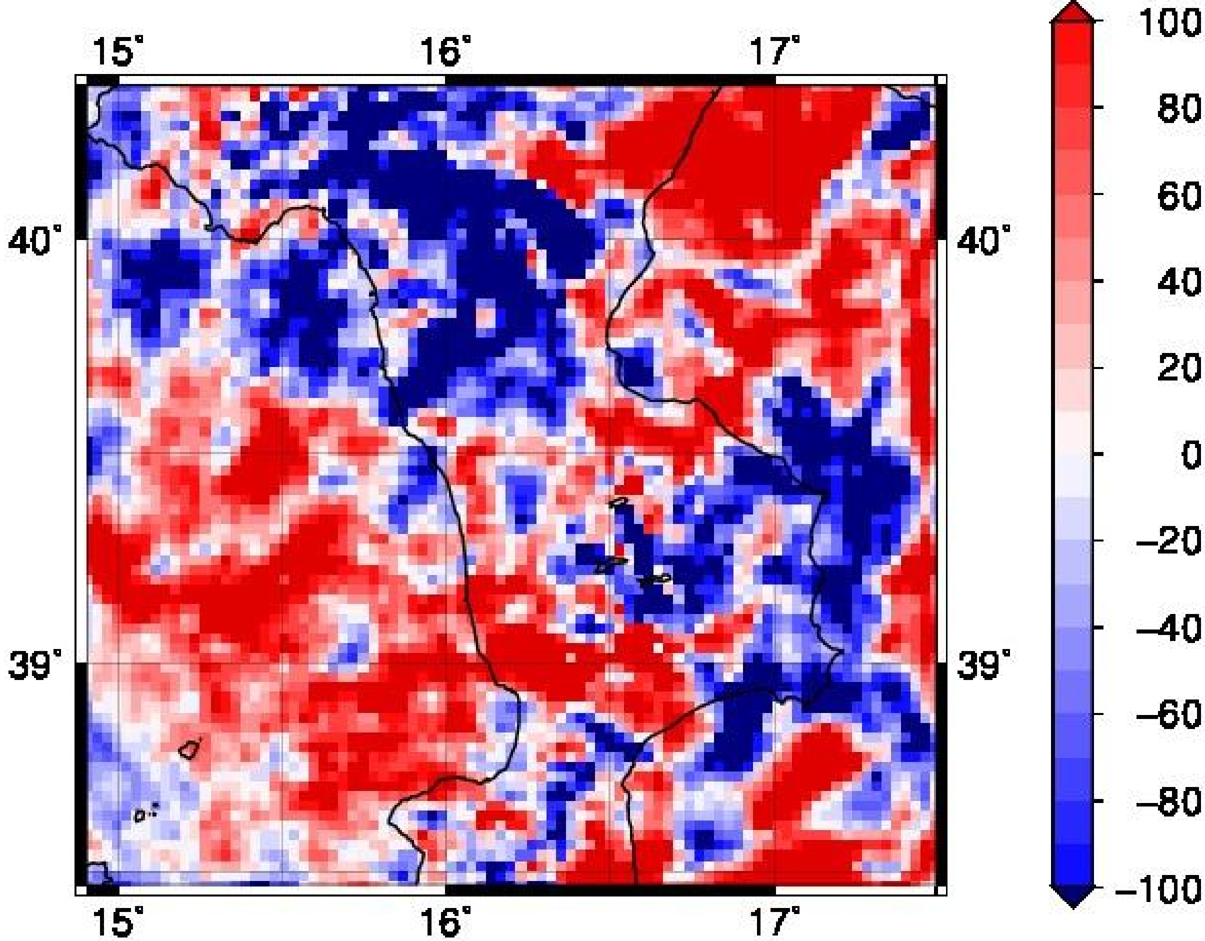
- Averaged precipitation maps



Results

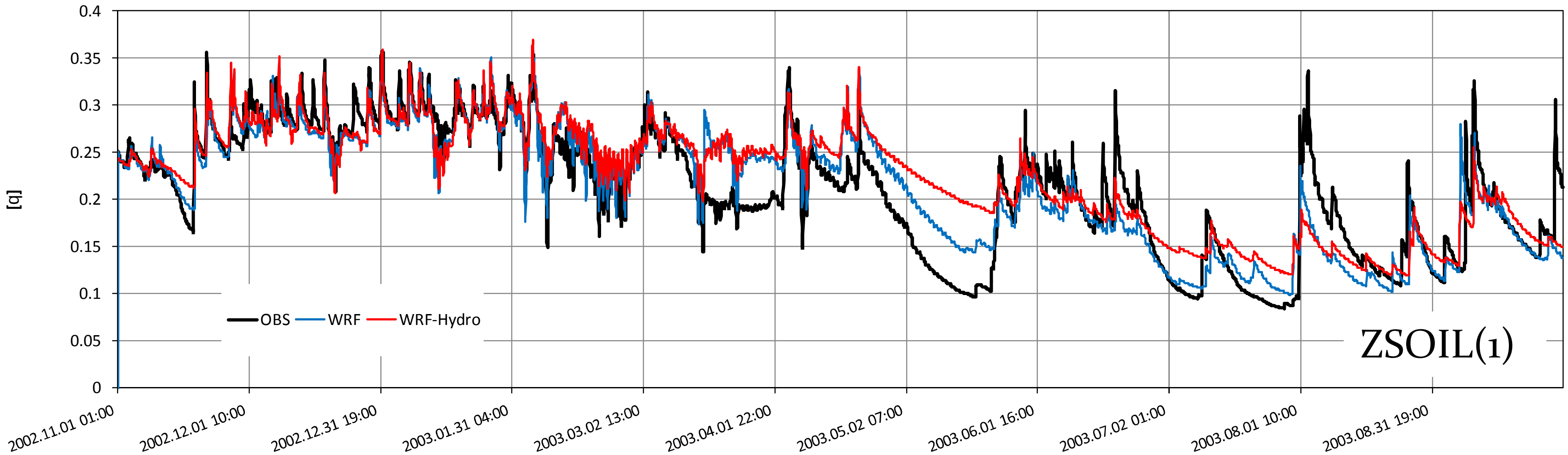
- Averaged precipitation maps

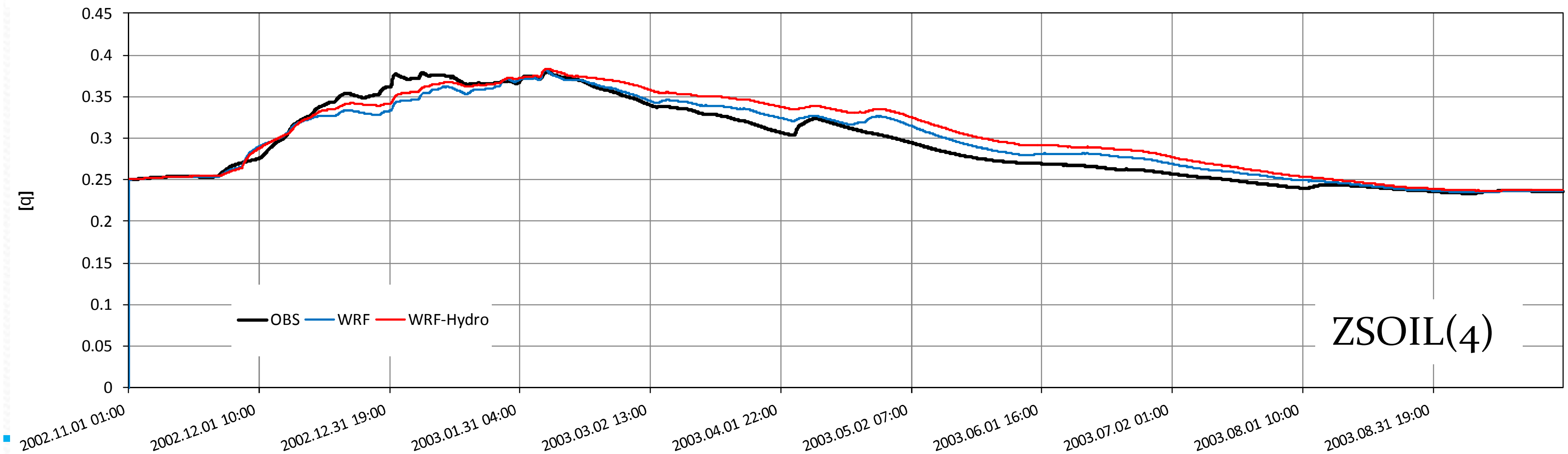
WRF-Hydro - WRF



Results

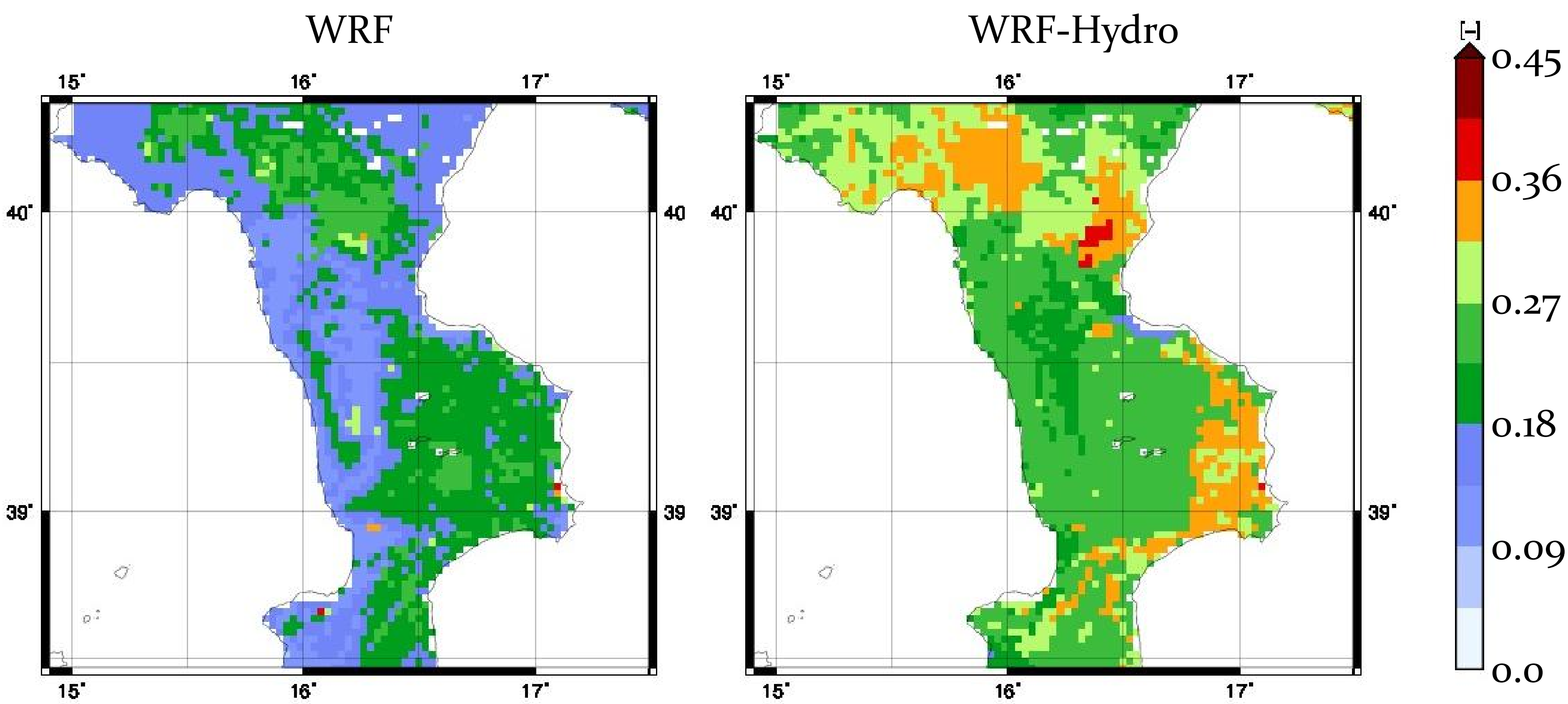
- Soil moisture





Results

- Soil moisture May 1, 2003



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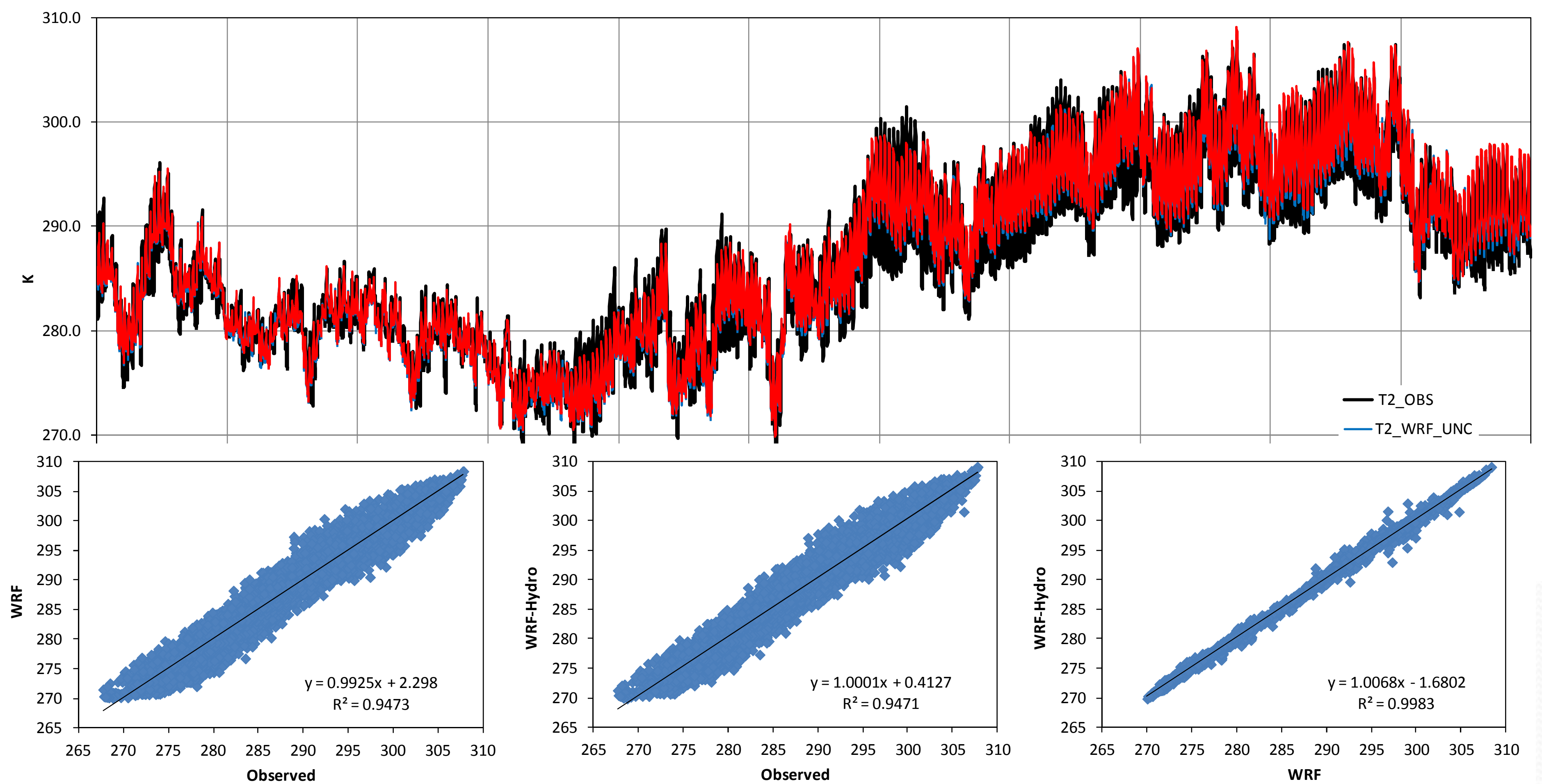
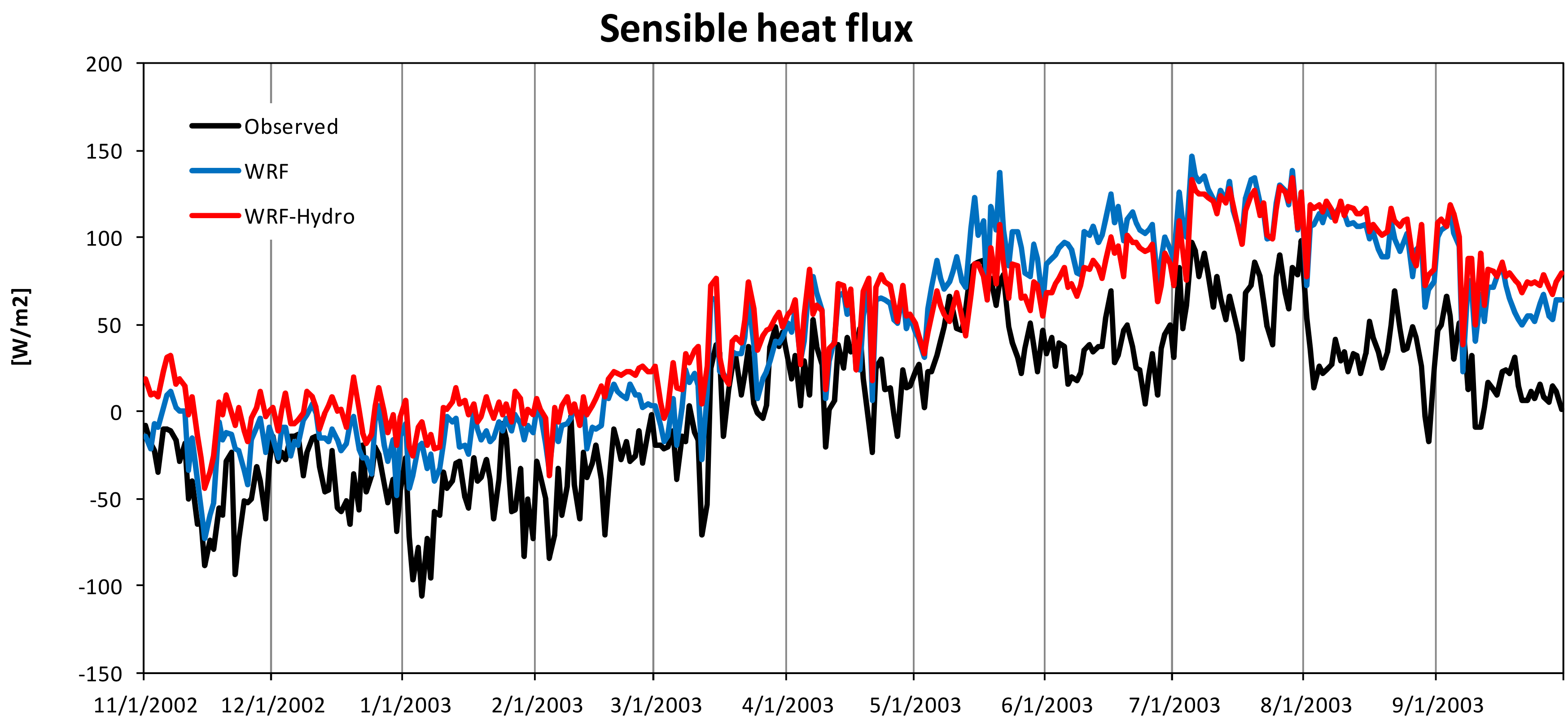
Results

- Temperature



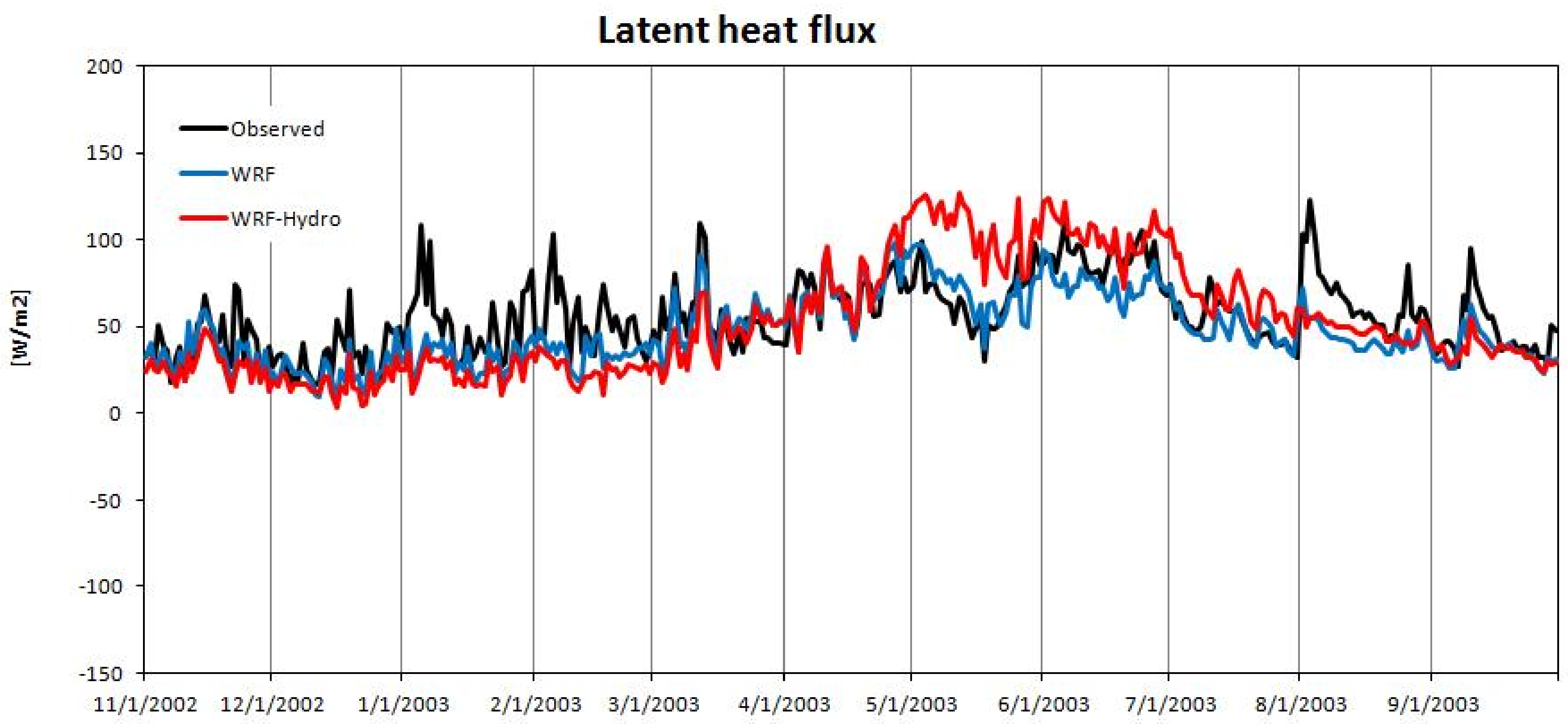
Results

- Heat fluxes



Results

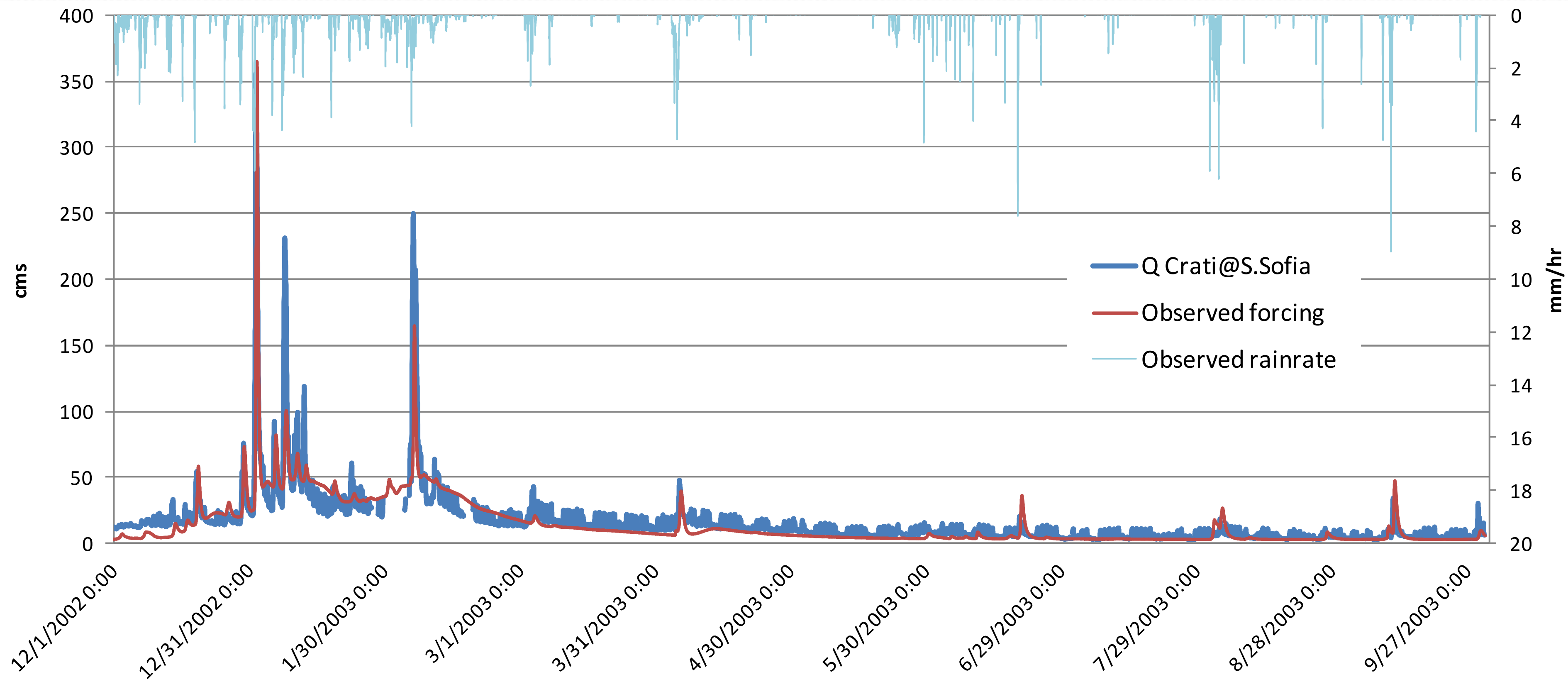
- Heat fluxes



Results

- Streamflow

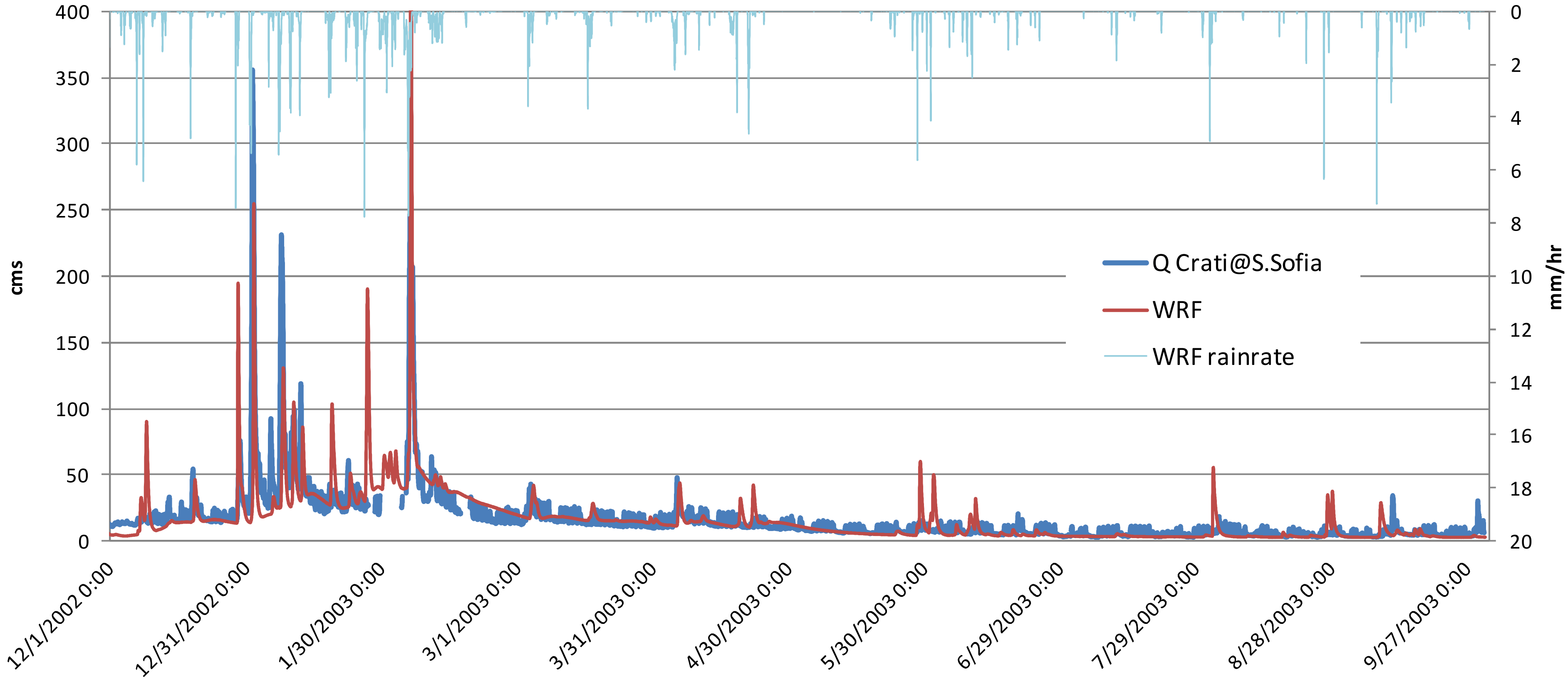
Obs forcing N.S. = 0.80



Results

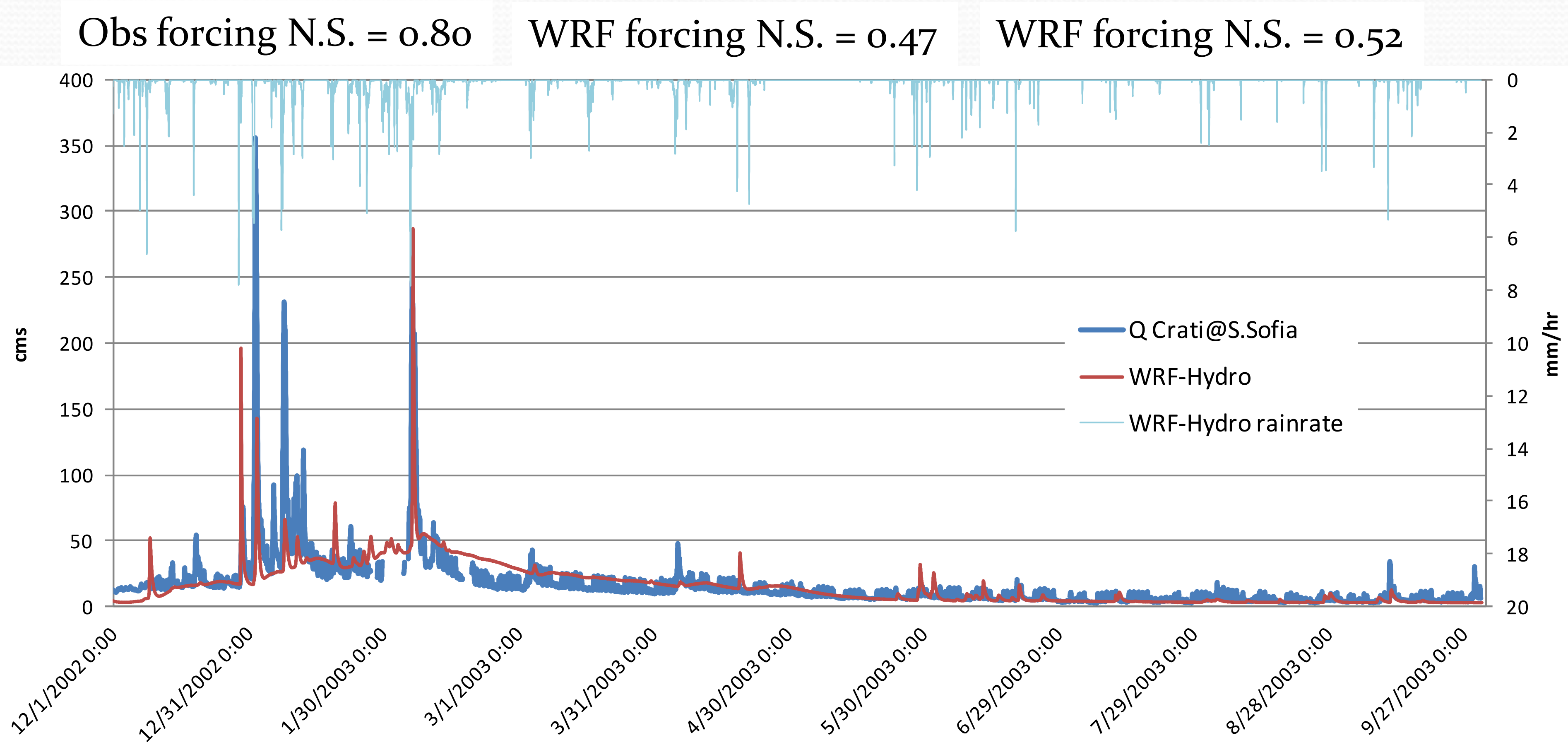
- Streamflow

Obs forcing N.S. = 0.80 WRF forcing N.S. = 0.47



Results

- Streamflow



Conclusions

- Reliability of stand-alone WRF-Hydro hydrological model in a Mediterranean catchment
- Reliability of one-way and fully coupled approaches
- Improvement of simulated precipitation for specific conditions with fully coupled approach
- Meaningful differences in soil moisture distribution, gw inflow, fluxes…
- Need to understand better when fully coupled approach is definitely better (e.g. classifying the events – convective or weather front…)