Comparison of dynamical and stochastical downscaling in the framework of ALADIN

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Motivation

Goal: Application of ALADIN-VIENNA ($\Delta x \cong 10$km) precipitation forecasts in Alpine watershed hydrology

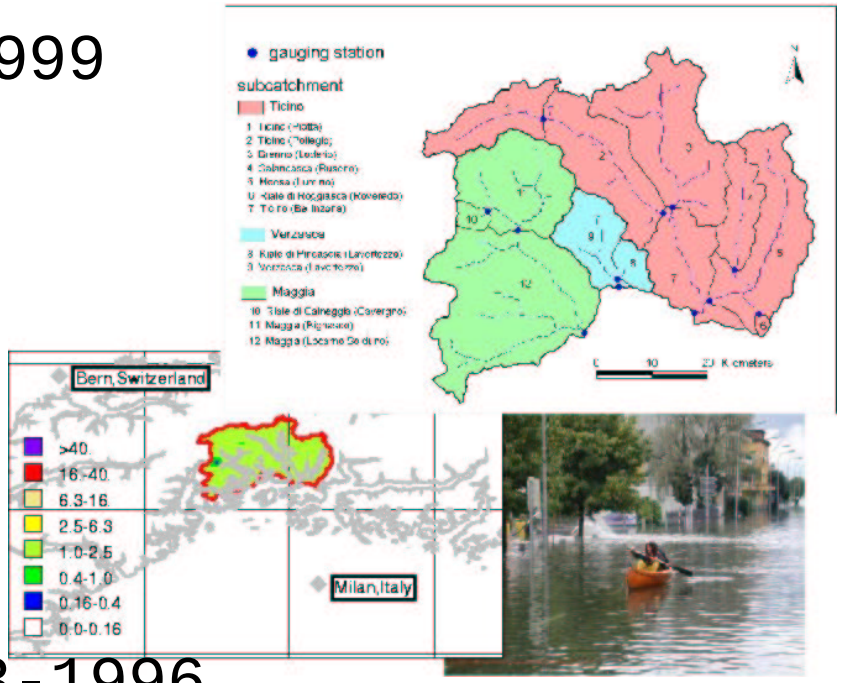
Problem: Scale difference between LAM and hydrological model!

Parts:
- Problem
- Deterministic downscaling
- Stochastic downscaling

Hydrological simulation

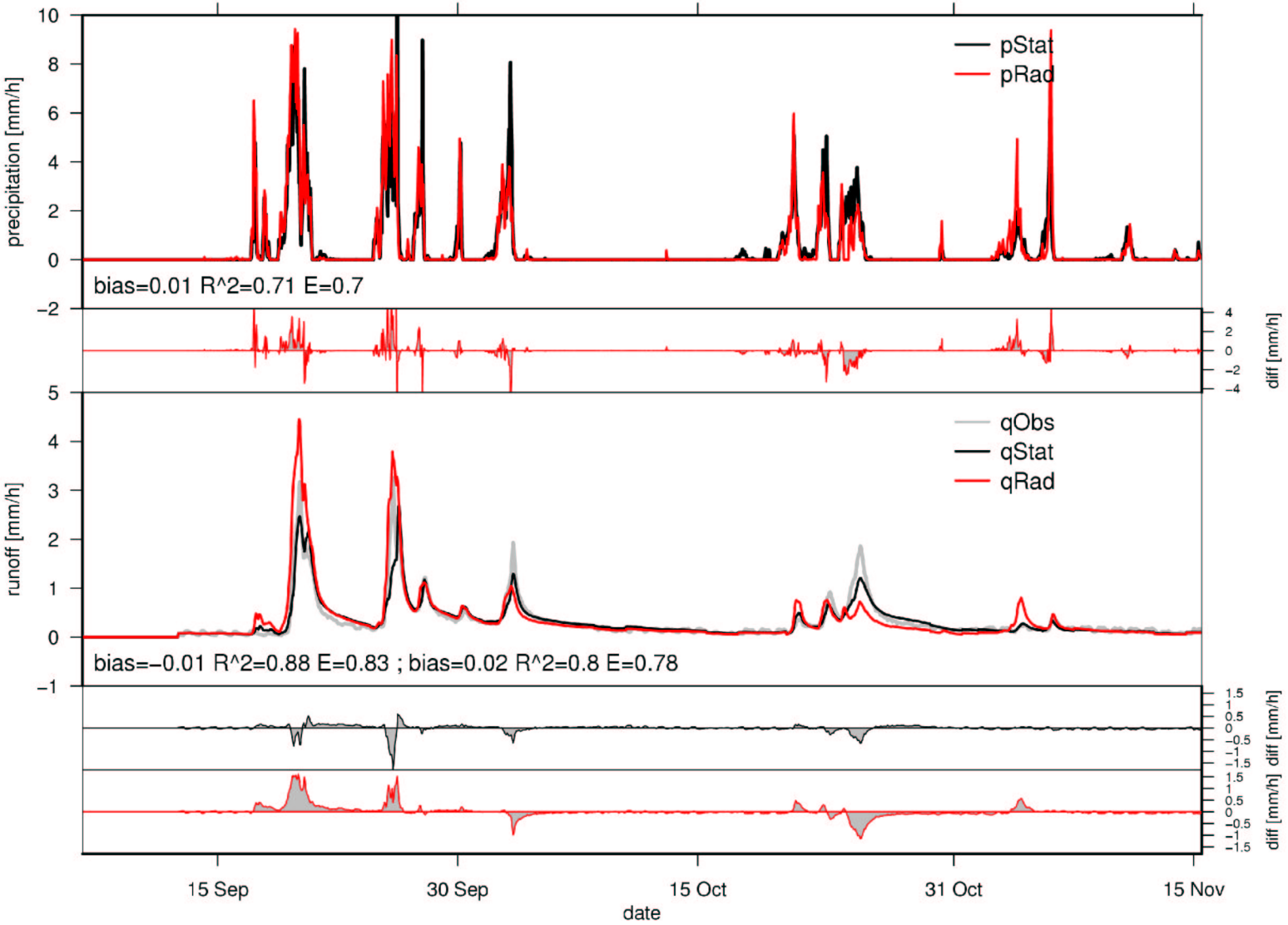
Model: WaSiM-ETH

target area: Ticino-Verzasca-Maggia watershed
(total area: 2627km^2)
period: MAP SOP, autumn 1999



WaSiM-ETH:

- Grid-based (Δx=500m)
- Δt=1h
- Detailed physics
- calibration period: 1993-1996



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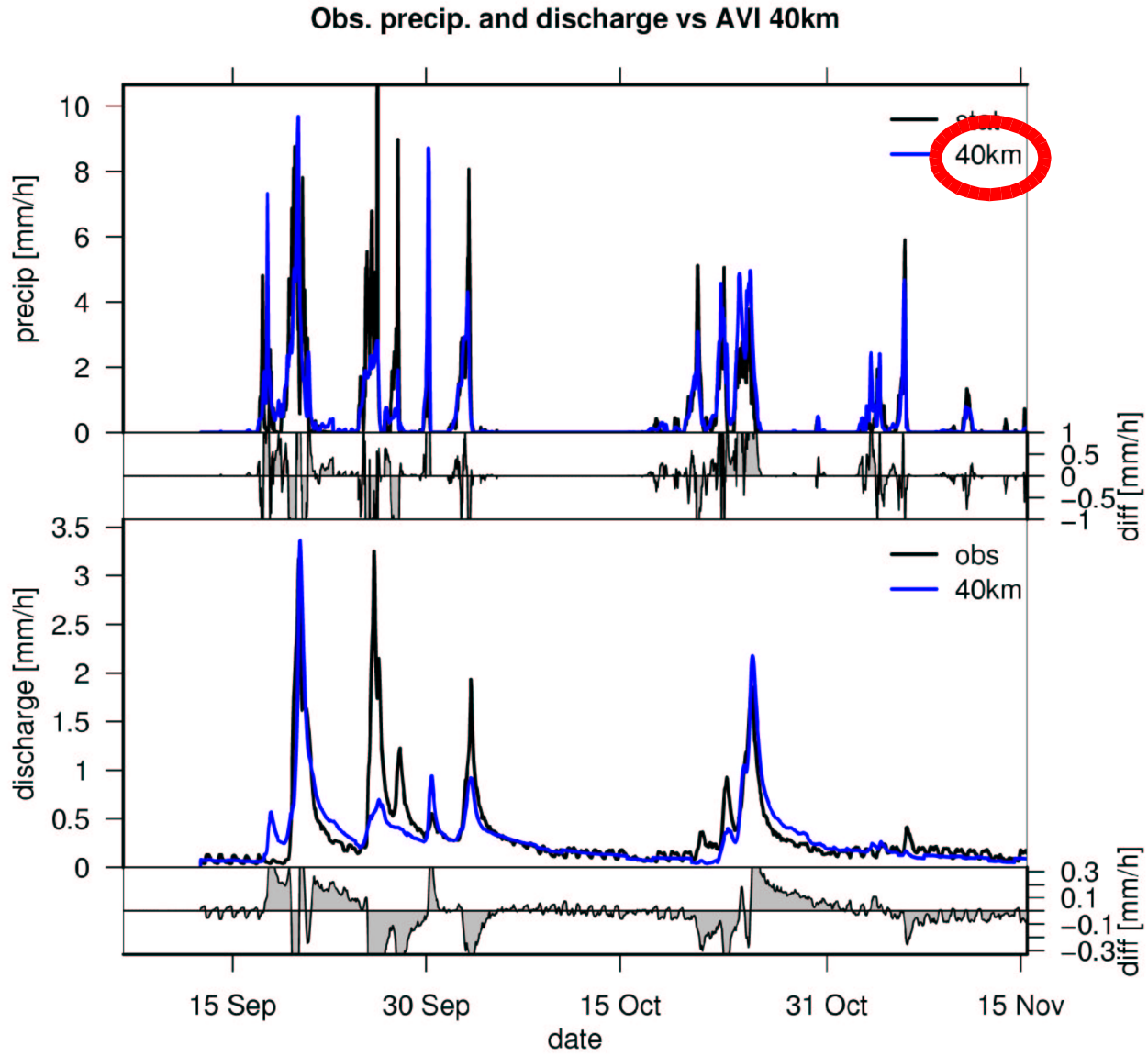
Hydrological forecasts need meteorological forecasts, esp. quantitative precipitation forecasts!

In case of short-range forecasts these should be provided by a LAM, e.g. by ALADIN.

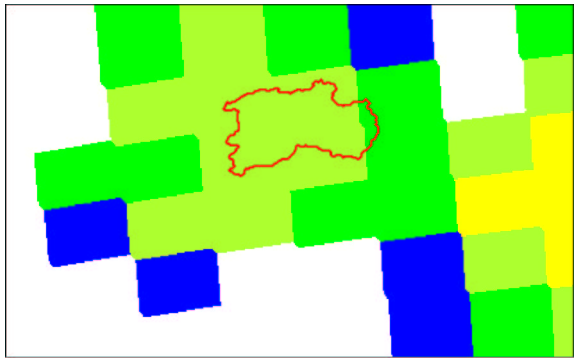
ALADIN-VIENNA -> WaSiM-ETH



Scale problem

hourly acc. precipitation fields:

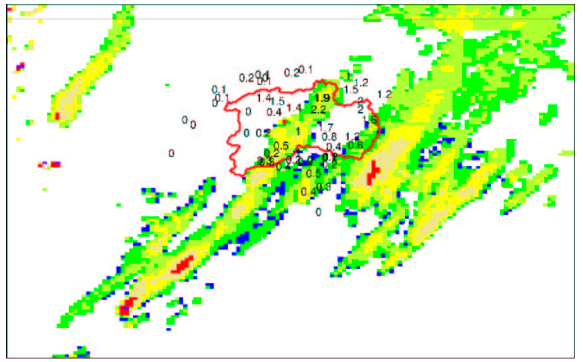
AVI 40km



Prec. [mm/h]

- >40.
- 16.-40.
- 6.3-16.
- 2.5-6.3
- 1.0-2.5
- 0.4-1.0
- 0.16-0.4
- 0.0-0.16

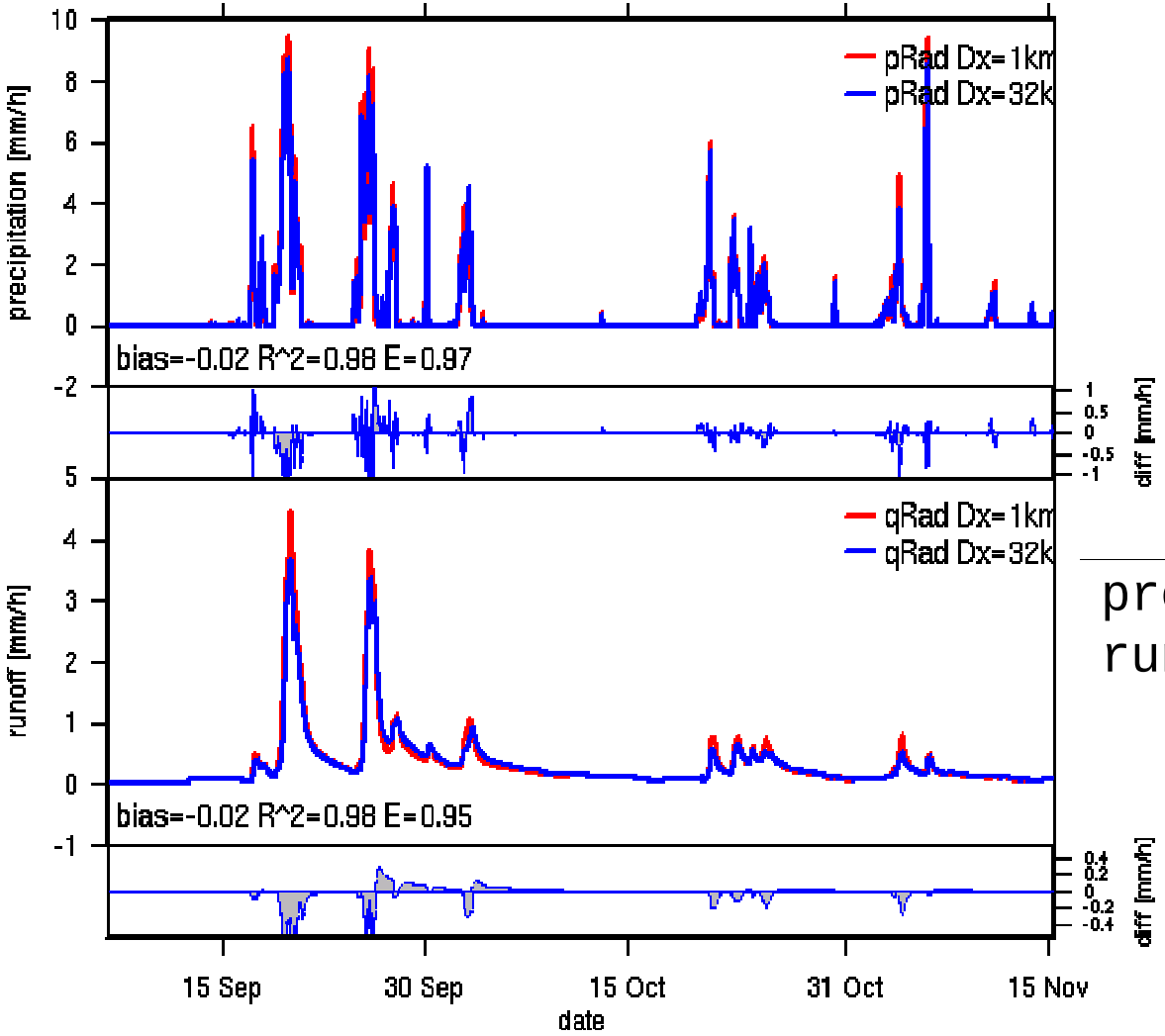
Radar 1km



P1: How to estimate area precip. rate?

P2: Coarse-grid AVI 40km fields underestimate spatial variability!

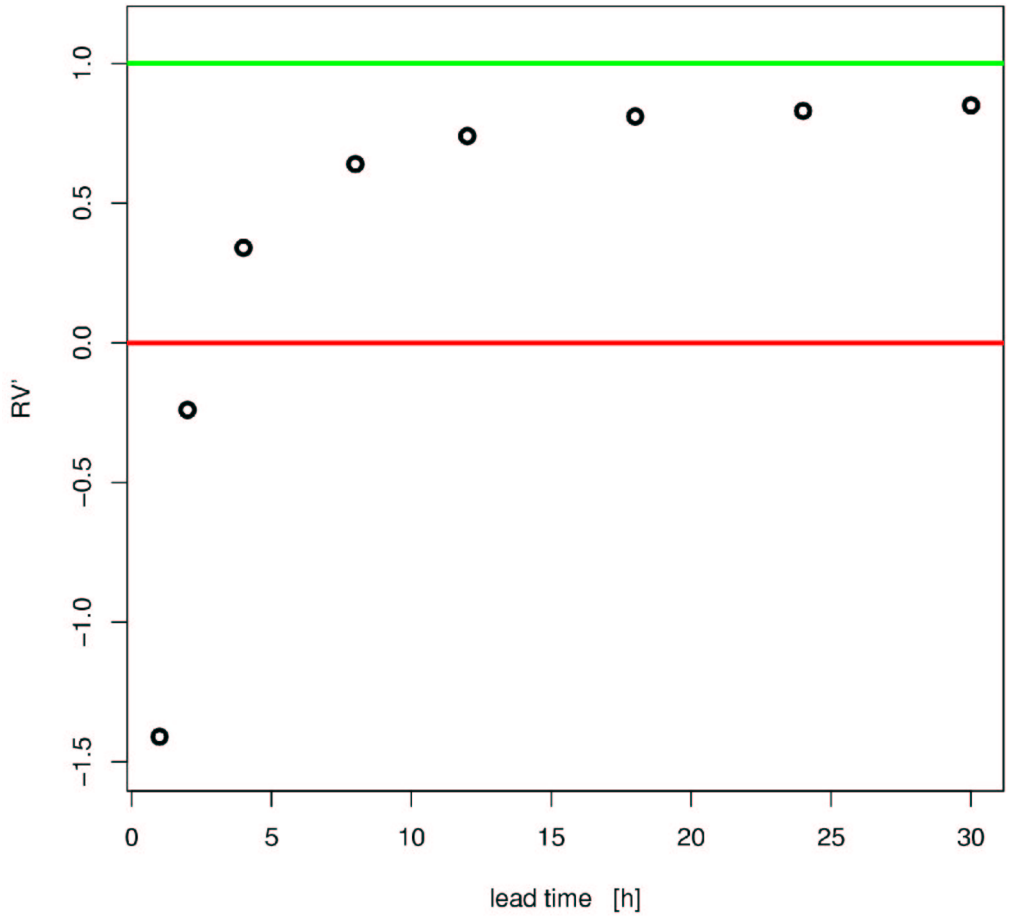
Runoff vs resolution of precip.



$$RV' = 1 - \frac{MAE(x, ref)}{MAE(ref\ (lag = 12h), ref)}$$

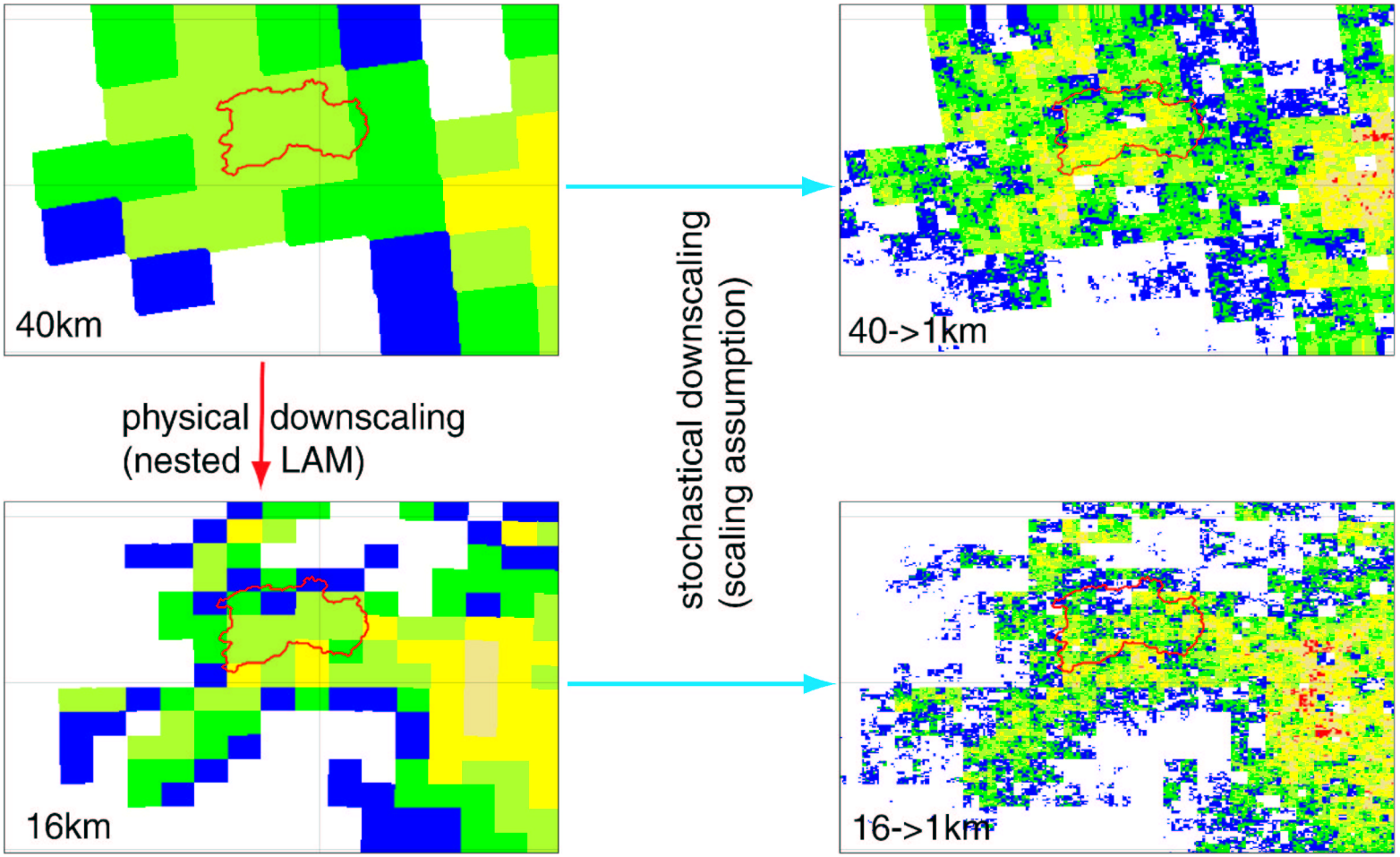
	1km	4km	16km	32km
precip	1	0.99	0.96	0.88
runoff	1	0.95	0.84	0.74

RV'(lead time; 32km)



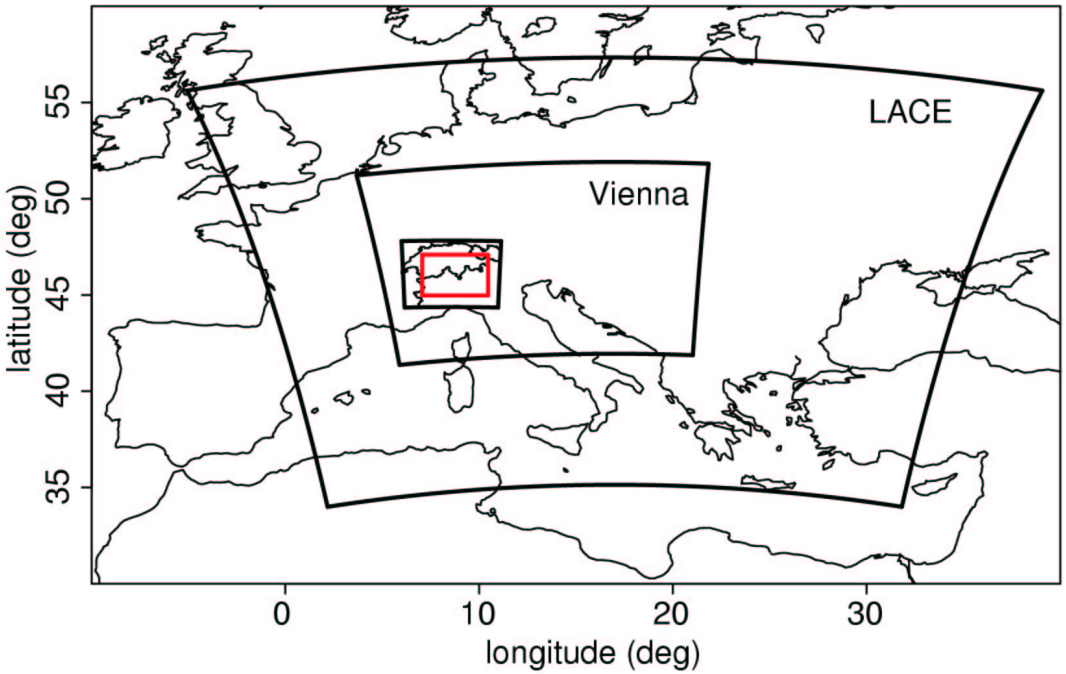
Downscaling is necessary!

Downscaling of AVI40km



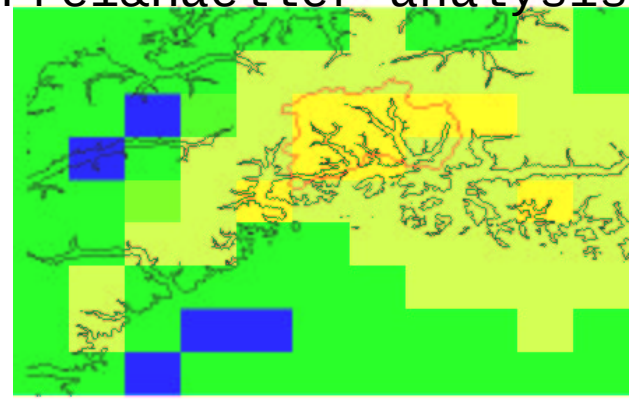
Experimental ALADIN-nh (c25)

- non-hydrostatic, sisl-3tl
- Δx=4km, Δt=75s, adjusted diffusion coeff.
- one-way coupling, 1h time step
- with convection parameterization



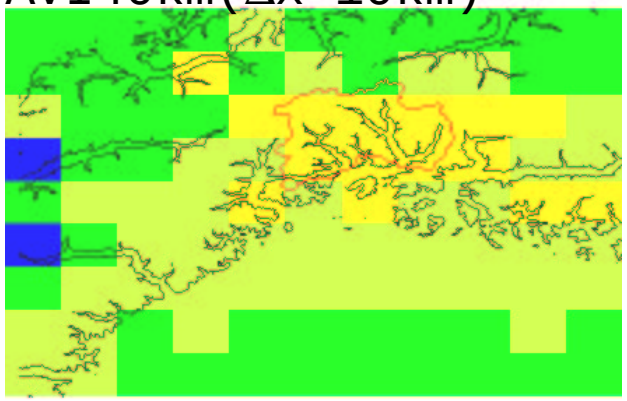
MAP SOP mean precipitation

Frei&Haeller analysis



Comparison at
the FH 25km grid!

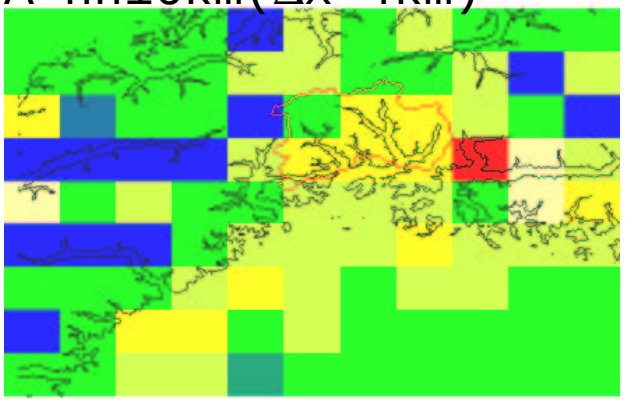
AVI40km(Δx=10km)



Prec
[mm/d]

- <0.1
- 0.1
- 2.0
- 5.0
- 10.0
- 20.0
- 50.0
- >100.0

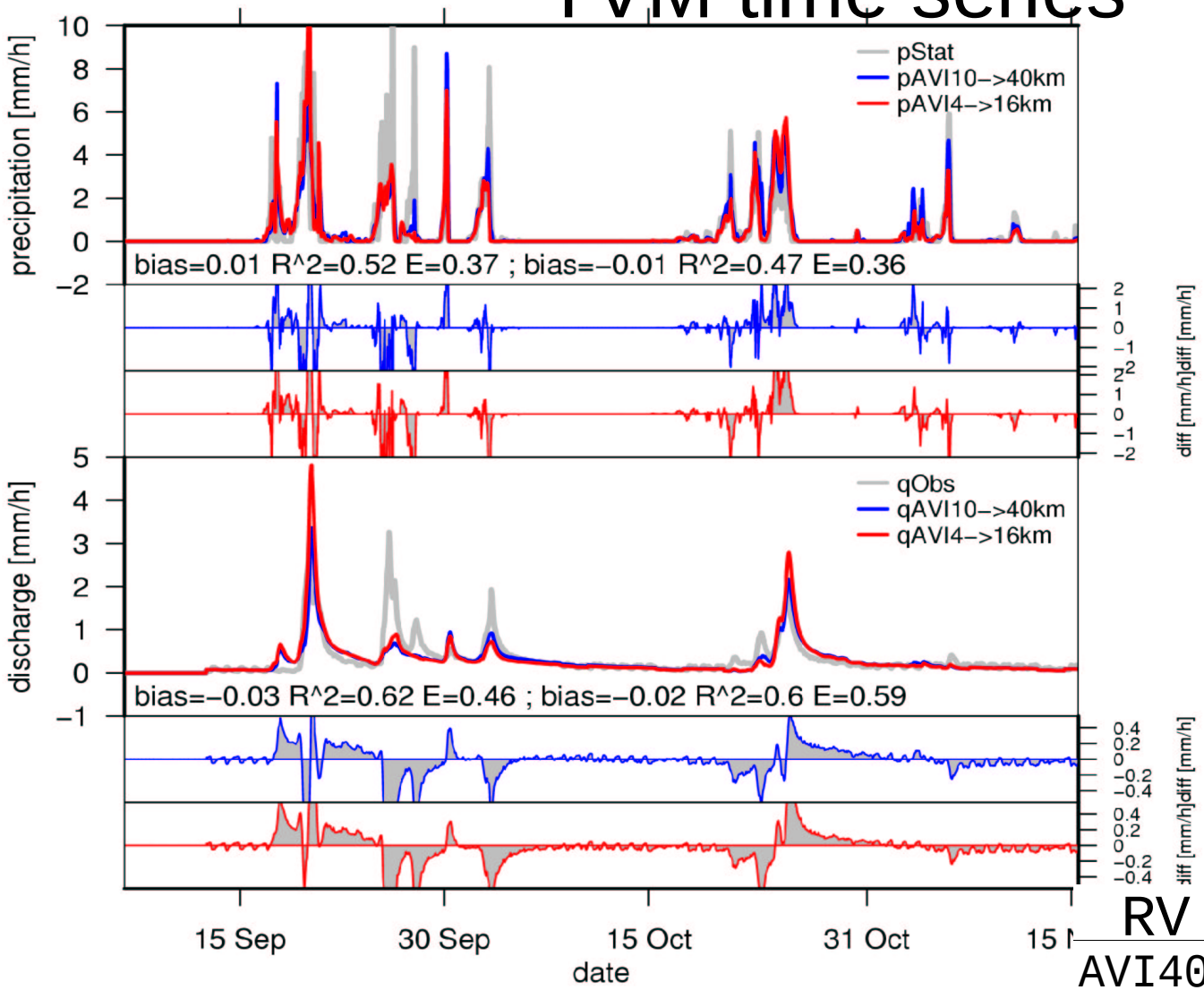
A-nh16km(Δx=4km)



$\langle TSS \rangle_{time}$=0.26

$\langle TSS \rangle_{time}$=0.20

TVM time series



RV':	precip	runoff
AVI40km	0.46	0.19
Anh16km	0.33	0.07

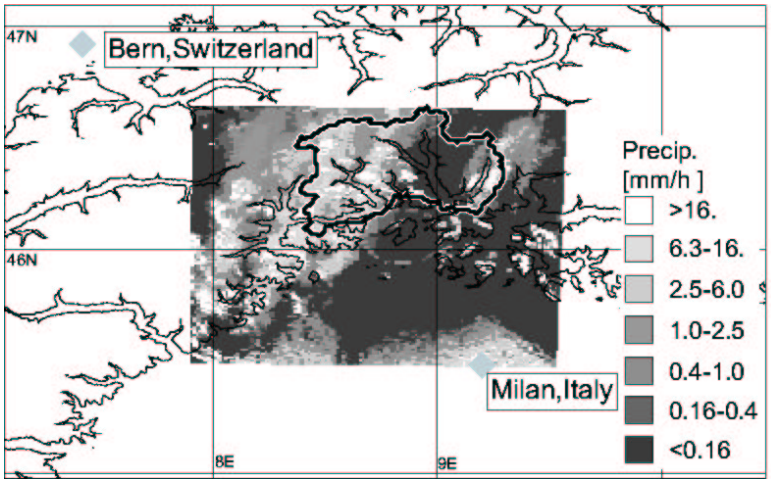
Hydrological simulations are not improved with physically downscaled precipitation input!

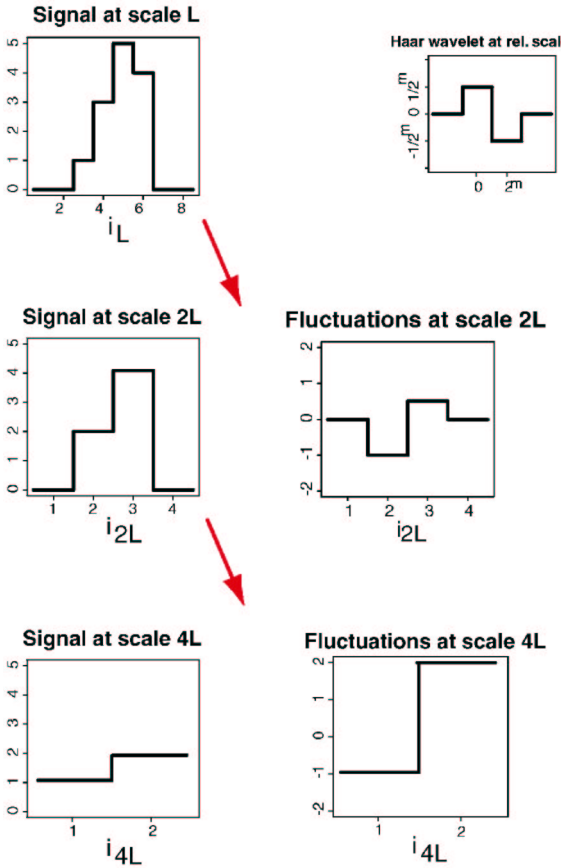
-> Systematic over-estimation of orographic impact!?

... stochastical downscaling:

Scaling investigation

Multiplicative multiresolution decomposition of radar data

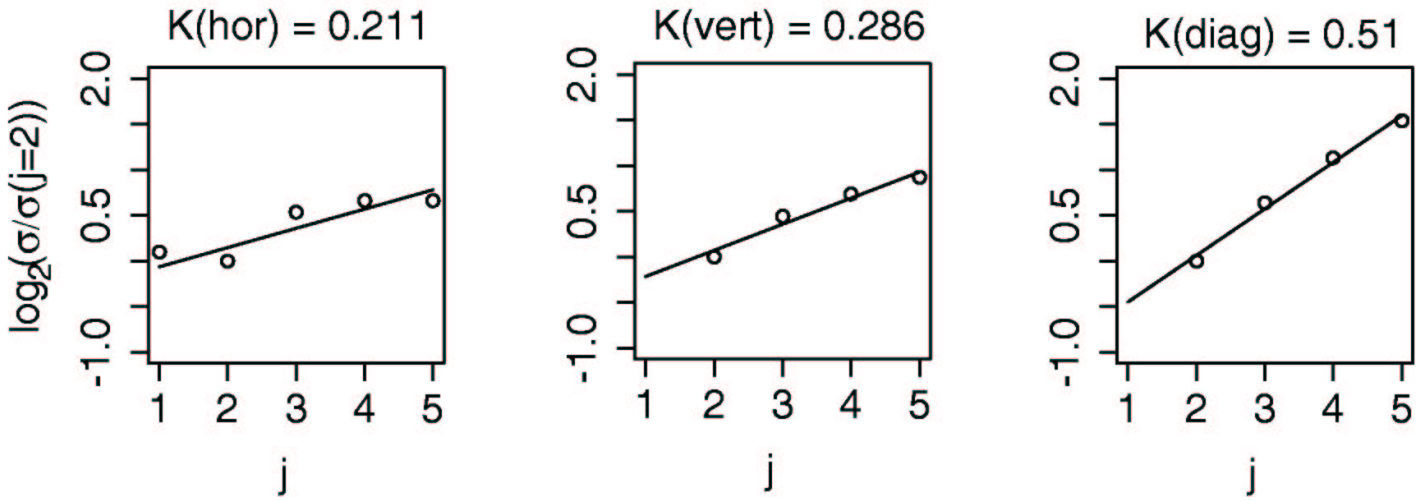




Precip. is positive: $f_j \rightarrow m_j = u_{j-1} / u_j$

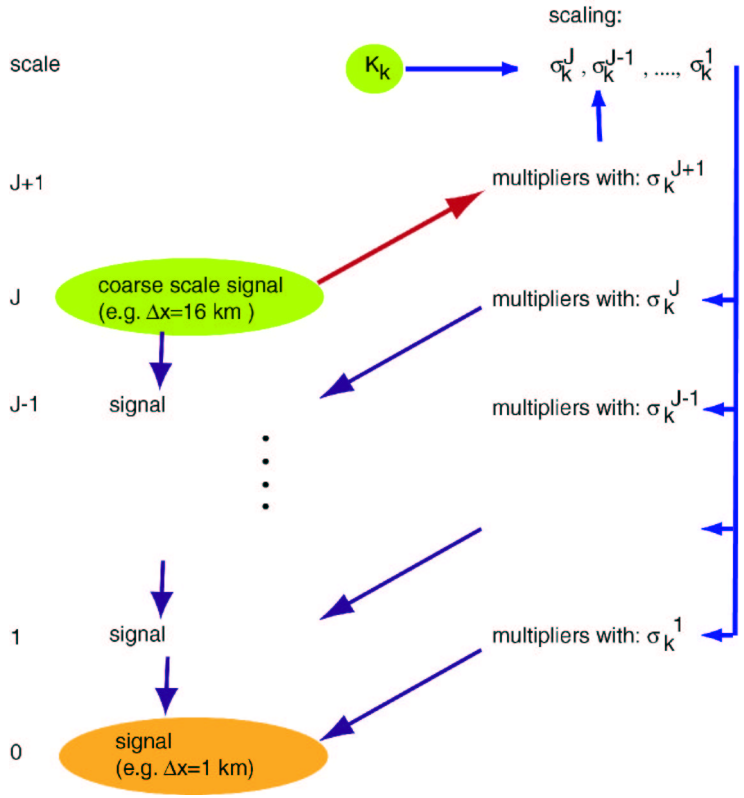
-> scale-invariance: $\sigma_{j_2}^{x} = 2^{(j_2 - j_1)K^x} \times \sigma_{j_1}^{x}, \quad x = , hor , vert , diag$

Variance of multipliers vs scale (resolution):



Stochastic downscaling scheme:

spatial

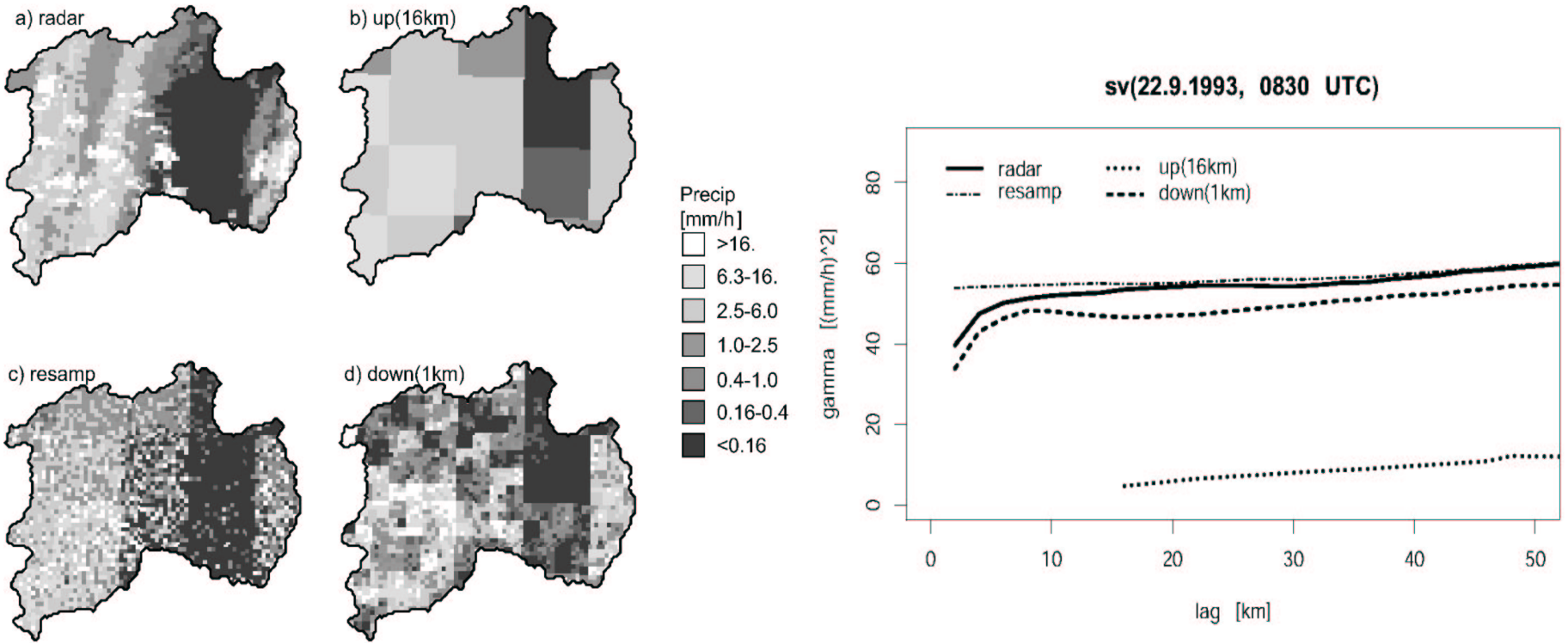


temporal

Persistence respected by multiplier persistence with probability P=P(Scale,v)

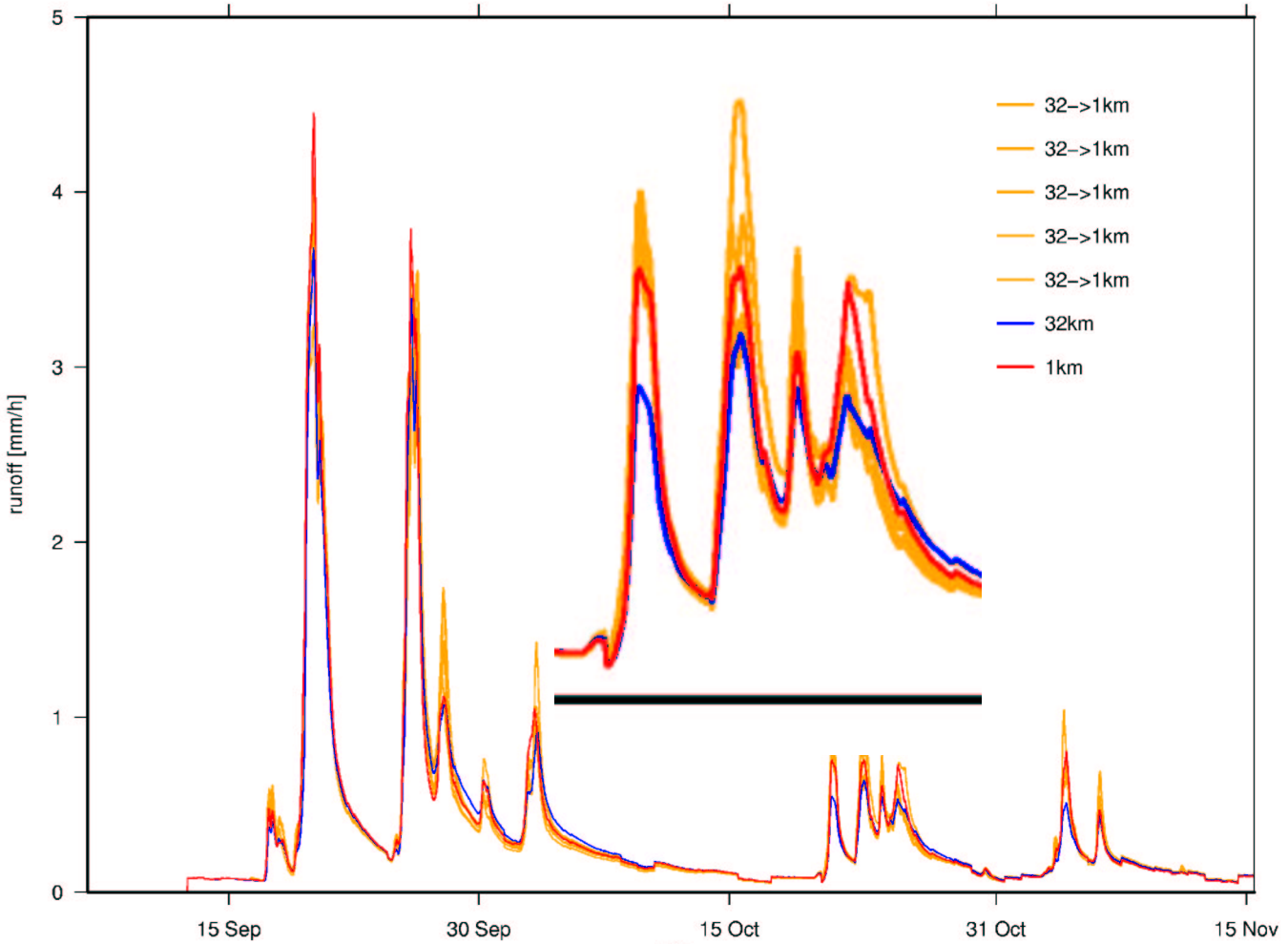
-> dynamical *anisotropic micro-canonical bounded multiplicative random cascade*

Evaluation



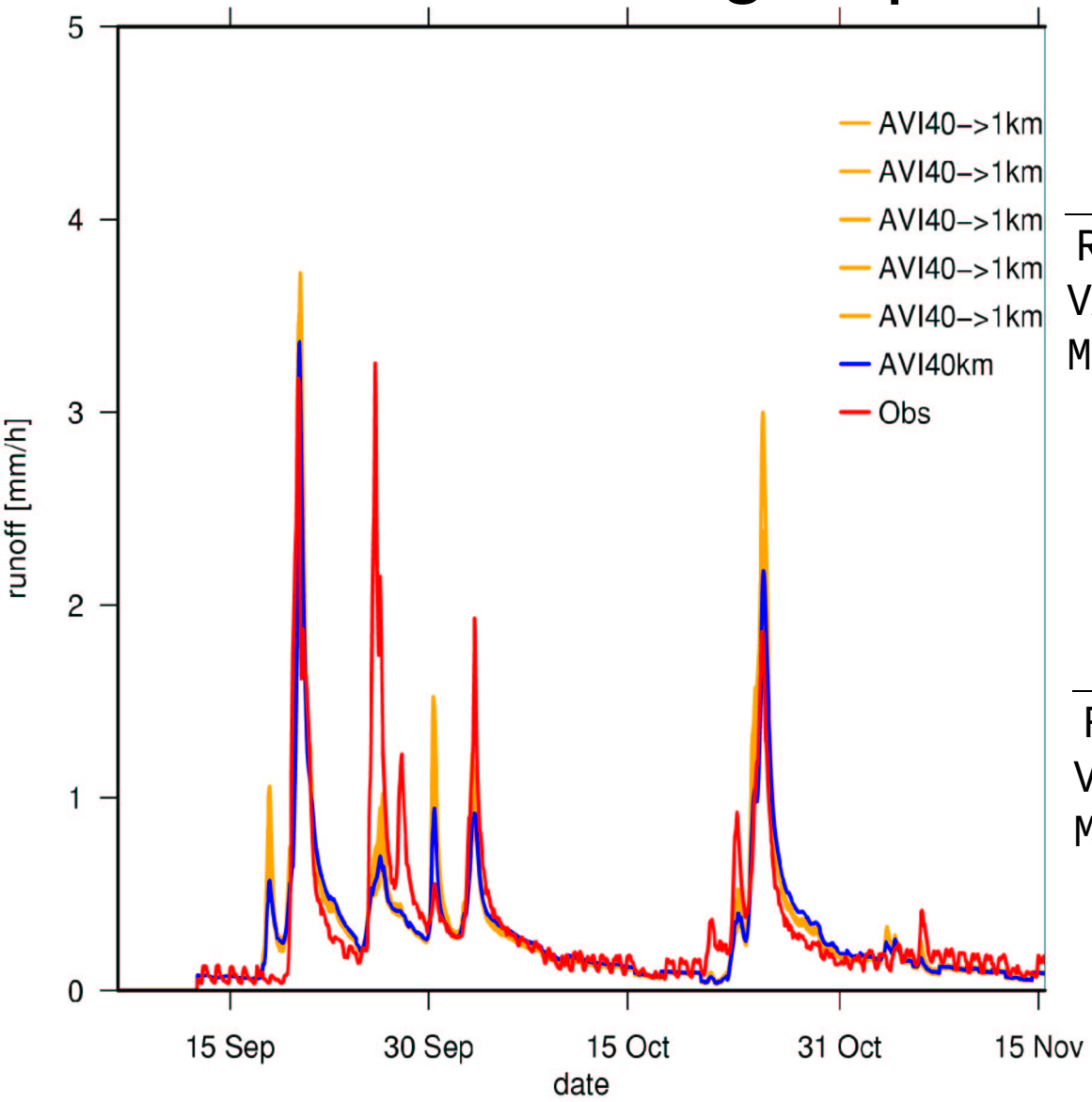
-> Ahrens, J. Geophys. Res., *108D8*, 2003

Test with radar data



	1km	32km	M1	M2	mean(M)
RV'	1	0.74	0.76	0.79	0.81

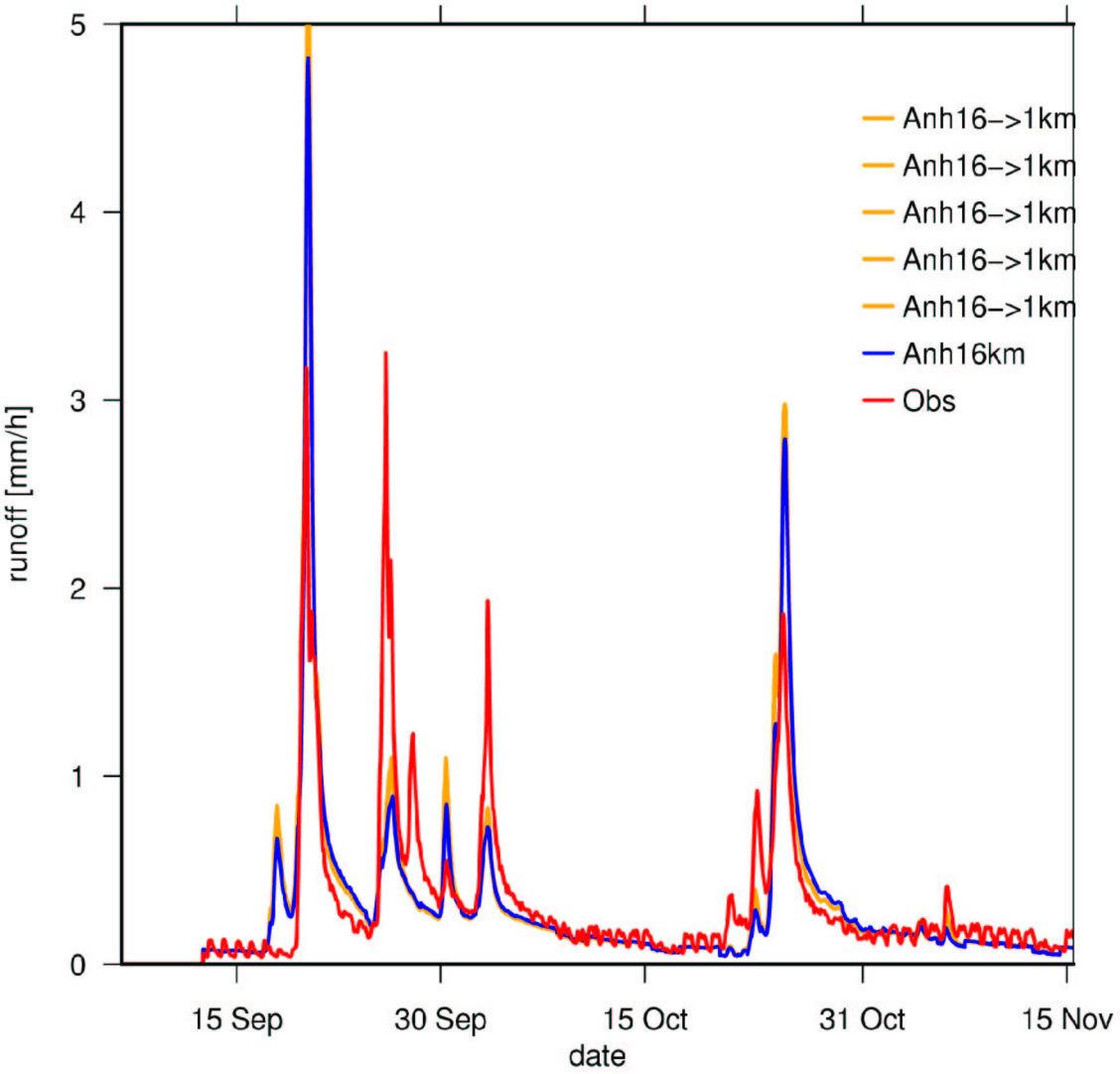
Downscaling-exp. with AVI40km



	Obs	40km	M1	M2	mean(M)
RV'	1	0.19	0.19	0.19	0.19
VAR	0.18	0.13	0.16	0.16	0.17
Mean	0.34	0.30	0.31	0.31	0.31

	Obs	40km	Stat	Rad	R32km
RV'	1	0.19	0.52	0.20	0.32
VAR	0.18	0.13	0.14	0.32	0.25
Mean	0.34	0.30	0.33	0.36	0.34

Downscaling-exp. with ALADIN-nh



	Obs	16km	M1	M2	mean(M)
RV'	1	0.07	0.06	0.04	0.06
VAR	0.18	0.24	0.28	0.29	0.28
Mean	0.34	0.32	0.33	0.33	0.33

Conclusions

- km-scale precipitation fields are necessary in hydrological applications
- deterministic forecasts (EPS) will be the *expensive future*, but are not robust nowadays
- stochastic downscaling (in combination with simple conceptional approaches, like orographic effects etc.) is cheap and robust
- most importantly LAM precipitation forecasts at the present-day LAM scale (10km) has to be improved

Acknowledgments
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