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Novel framework for merging radar and gauge precipitation in cold climates

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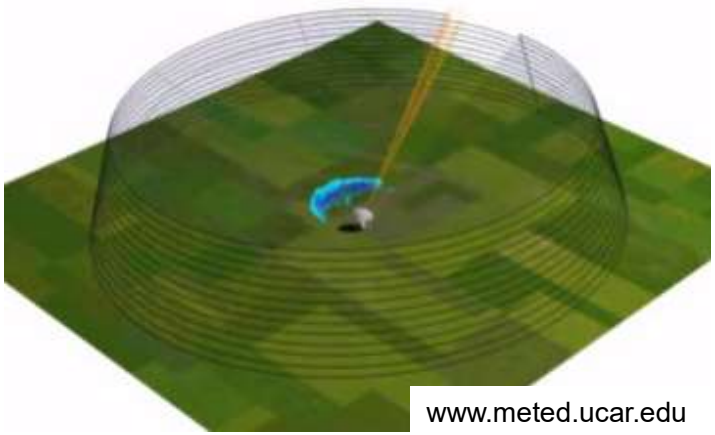
5th Conference on Modelling Hydrology, Climate and Land Surface Processes
Lillehammer, 17-19 Sept. 2019

Precipitation estimation

Raingauge, met.no

Radar scans ~250 km radius
7.5 min. resolution



www.meted.ucar.edu

- Gauges - point measurrements, Spatial interpolation is required

- Radars capture spatial variation relatively well despite errors in quantitative information

Weather radar, Norway (met.no)

Merging Radar and Gauge Precipitation

- Merging is not new - It is as old as the arrival of weather radar data for hydrology

- Earlier focus – Correct bias in radar precipitation estimation using gauge observations. (e.g. Mean Field Bias (MFB) correction)

- Sudsequent research focus – To further improve the spatial interpolation of gauges using spatial variability measured by radar.

  (e.g. Geostatistical merging methods)

Radar – Secondary Information

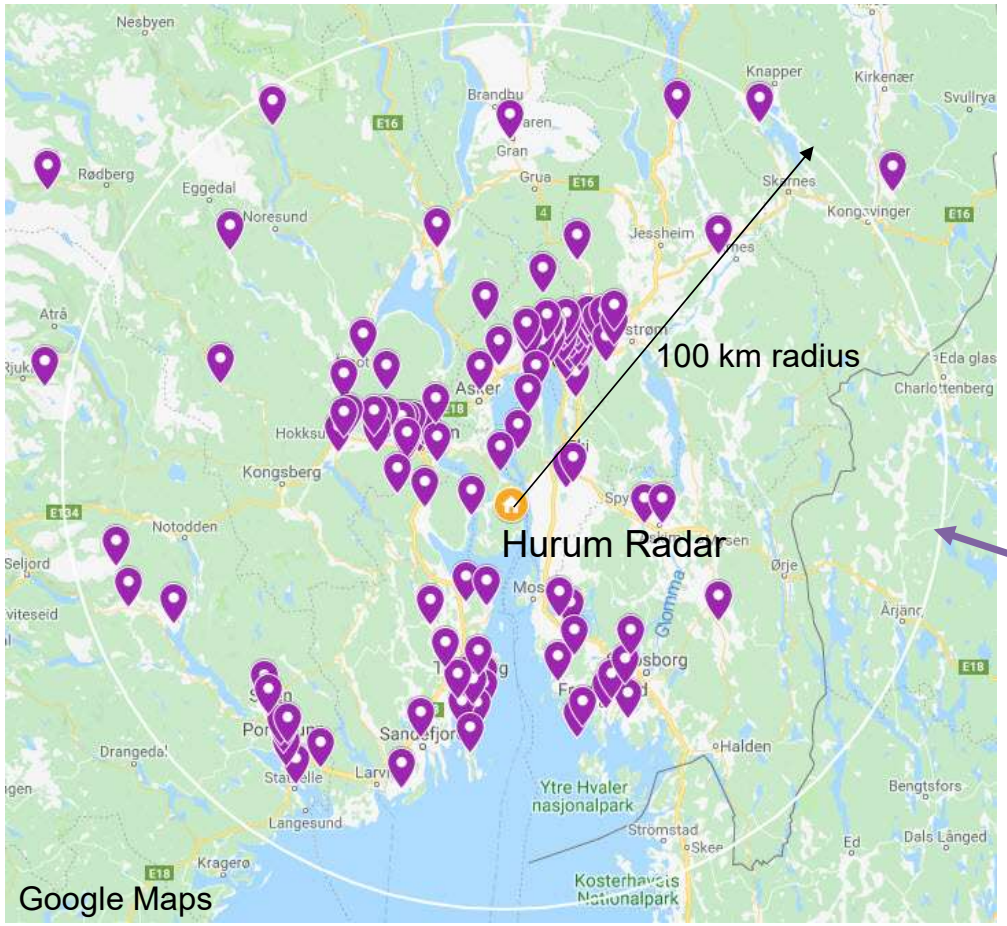
Innovative framework for merging

❖ Forecast combination approach

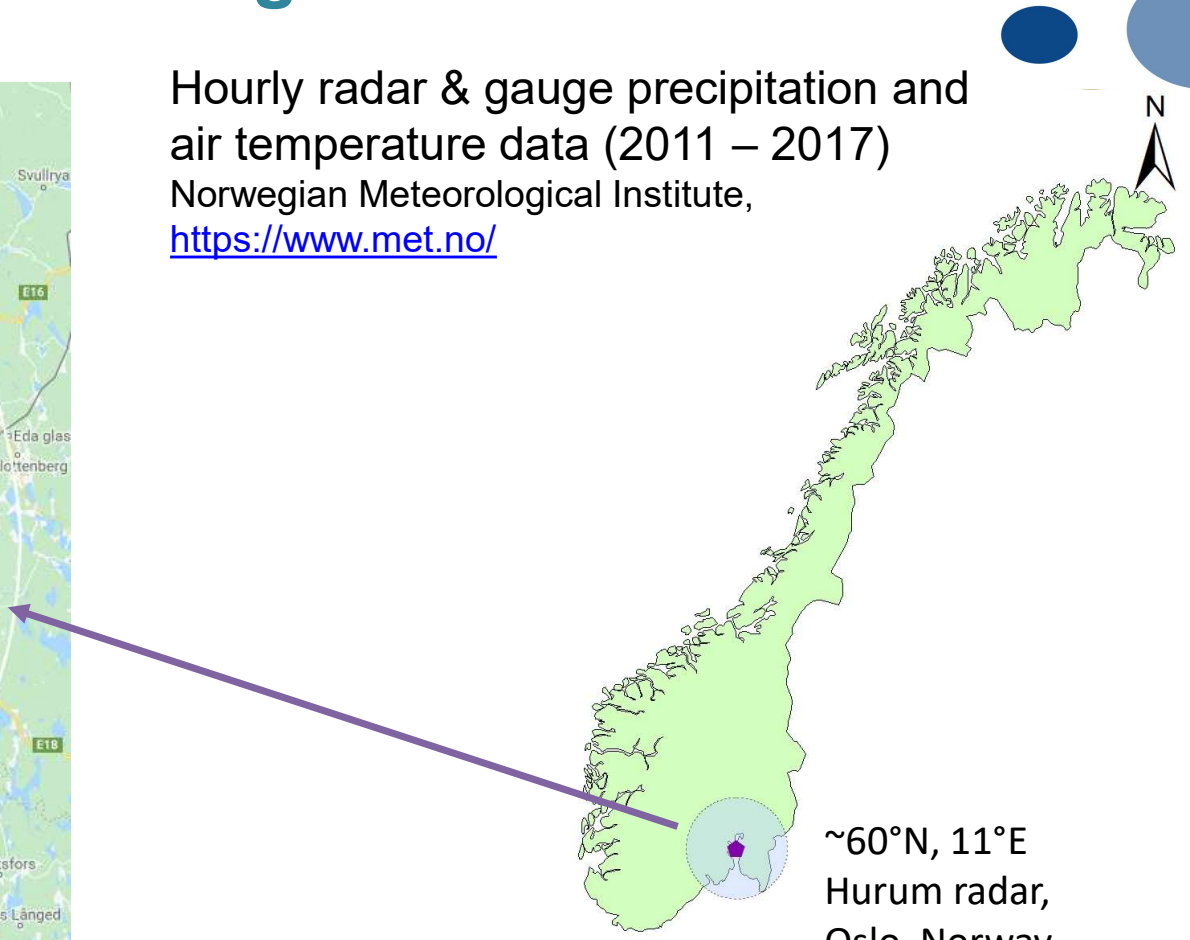
To merge – the study adapted a forecast combination approach.

- ➢ Here, the two sources of precipitation are considered equally important.

Study area, Hurum radar coverage



Hourly radar & gauge precipitation and air temperature data (2011 – 2017)
Norwegian Meteorological Institute,
https://www.met.no/

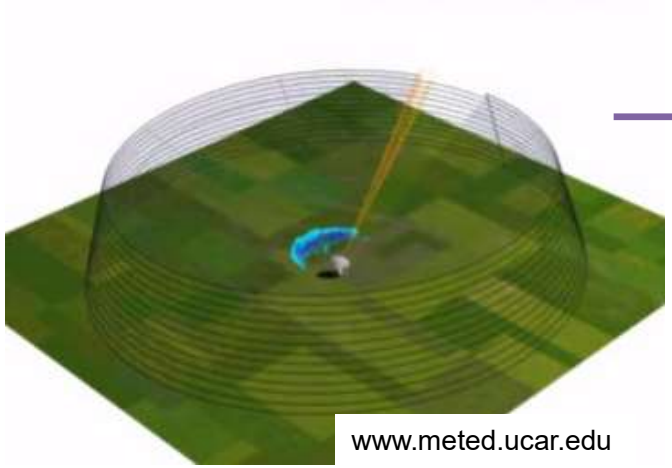


Innovative framework for merging

- Correct the hourly radar precipitation rate before merging

"Merging must be applied as the last step in radar precipitation estimation process and all possible corrections should be applied first"
(Goudenhoofdt and Delobbe, 2009).

Reflectivity (Z) Precipitation rate (R) relationship



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$$Z = aR^b$$

(Marshall and Palmer, 1948)

- Parameters a & b vary with type and phase of the precipitation.
- Some cold climate countries (Finland, Canada) uses two sets (snow & rain).
- To account multiple snow types & mixture of snow and rain, many parameter sets may be required

Weather radar Rissa, Norway. Met.no

Does air temperature matter?

- Temperature is related to phase of the precipitation & ensuing reflectivity.
- Dielectric property of snow is different from rain & it varies with temperature.

Hypothesis

Air temperature – Covariate in radar precipitation estimation for cold climates.

Innovative part of the study

Nonparametric approach

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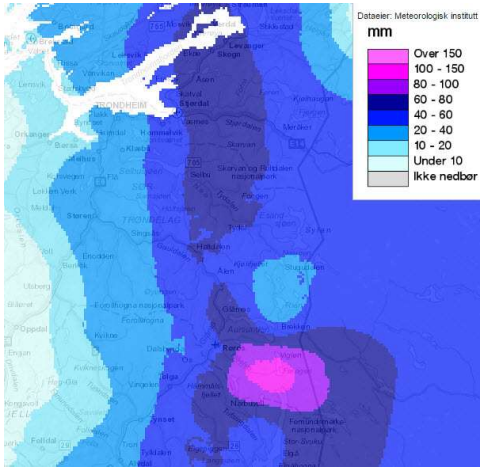
For systems where Physical relationships are less apparent

Sufficient observational records exist



Improved Quantitative Precipitation estimates

Nonparametric method

Conditional estimation of precipitation

- Radar precipitation rate & Air temperature - two covariates

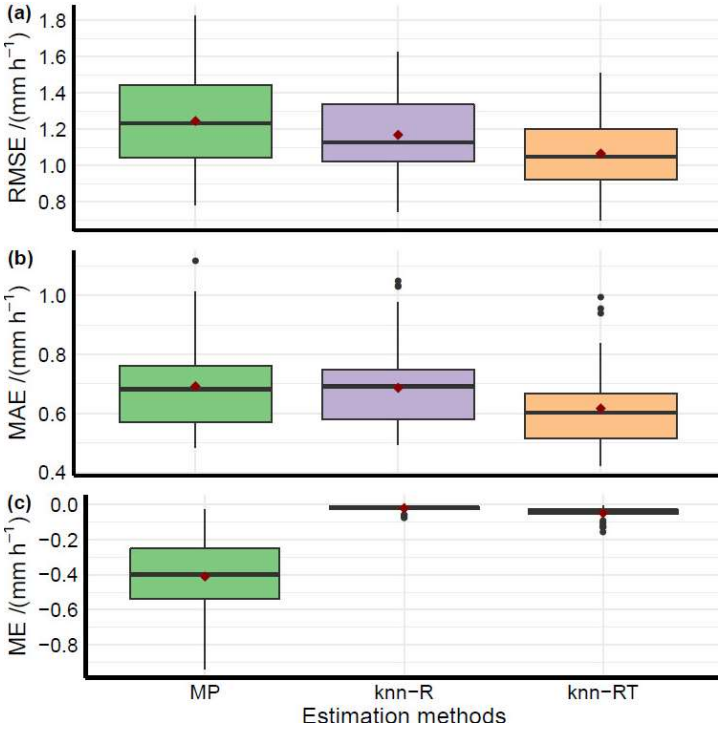
$$R_{est}(t)|[R(t),T(t)]$$

- K nearest neighbor (k-nn) method

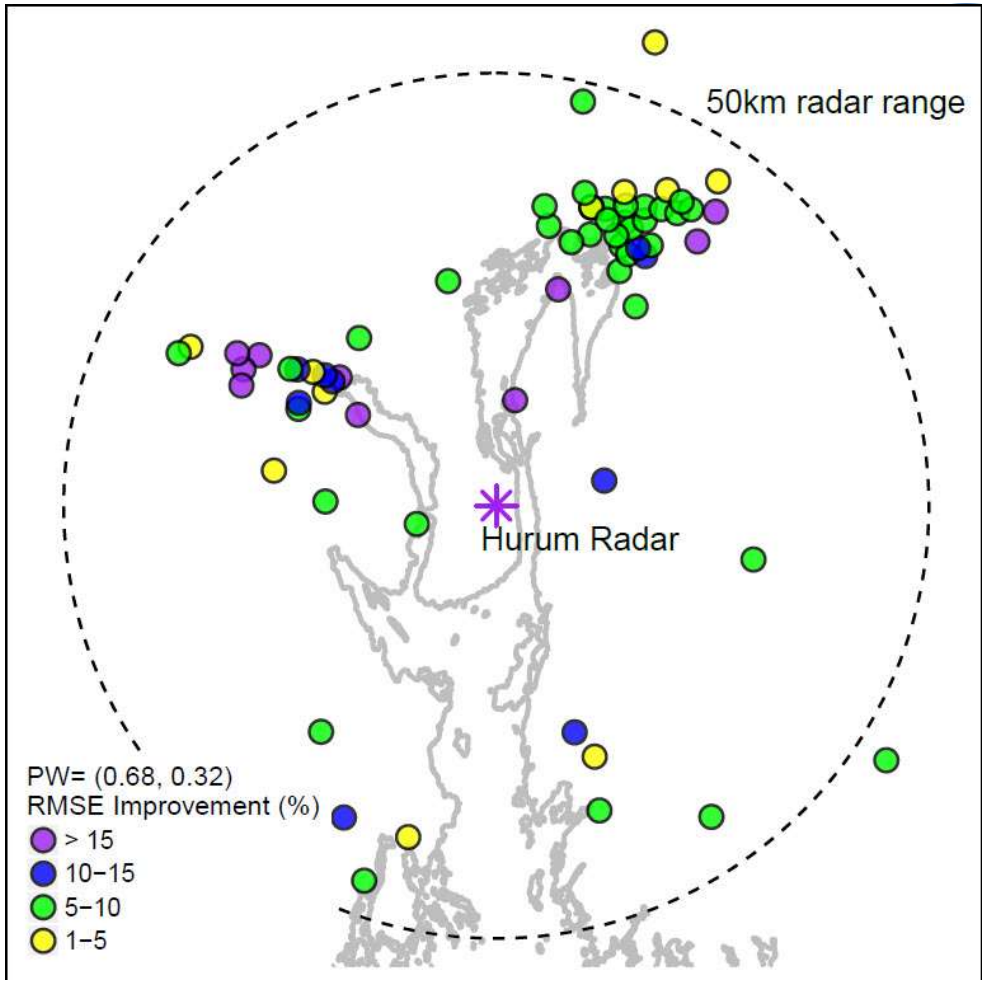
$$E\left(R_{\text{est}}(t)|[R(t),T(t)]\right)=\sum_{k=1}^{K}\frac{\frac{g_k}{k}}{\sum_{j=1}^{K}\frac{1}{j}}$$

Results from the study

- ✓ Bias is noticeably reduced
- ✓ 15 % improvement in RMSE with air temperature
- ✓ 80 % of the locations showed clear improvement



Sivasubramaniam et al., (2018)



Sivasubramaniam et al., (2018)

Results from the study – Published

Hydrol. Earth Syst. Sci., 22, 6533–6546, 2018
https://doi.org/10.5194/hess-22-6533-2018

Hydrology and Earth System Sciences
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Estimating radar precipitation in cold climates: the role of air temperature within a non-parametric framework

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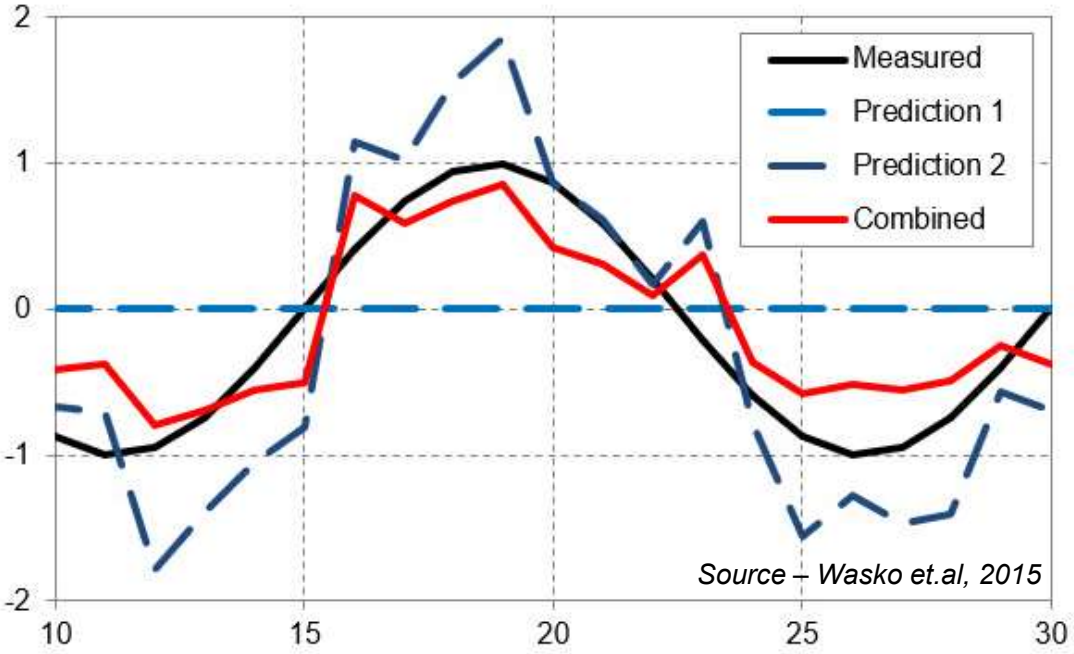
Merging the two sources of precipitation

- Corrected radar precipitation – k-nn estimates
- Gauge precipitation

- Using Forecast combination approach

Forecast Combination approach

- Roots in Economic forecasting

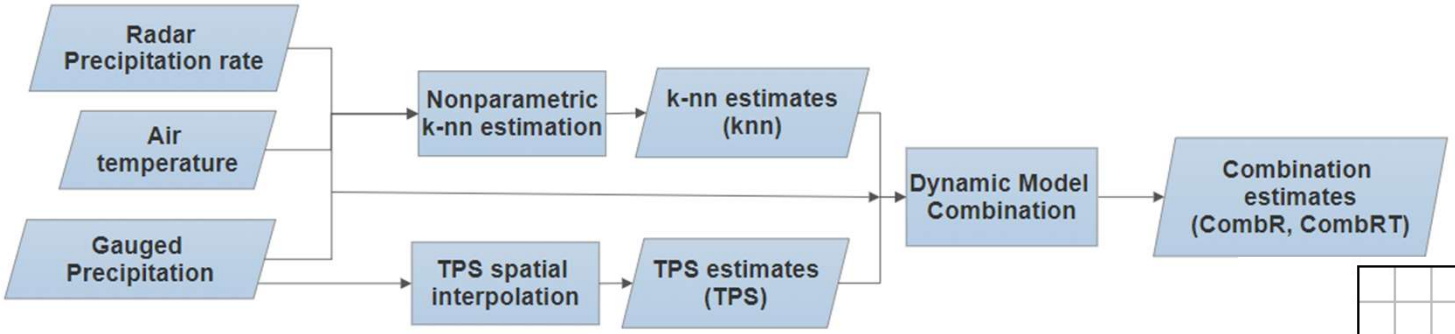


Bates and Grangner, 1969

$$y_c = w f_1 + (1 - w) f_2$$

$$w = \frac{\sigma_1^2 - \rho\sigma_1\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}$$

Merging within dynamic forecast combination framework



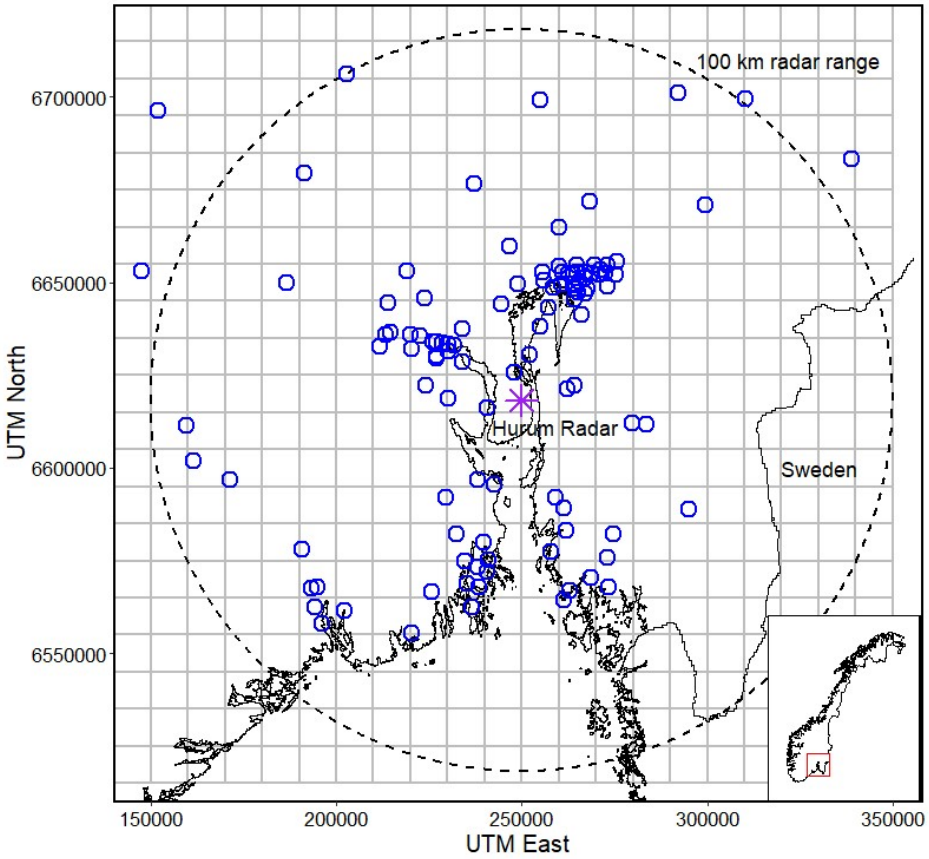
Combination

$$P_{CombRT,x,y}(t) = W_{k-nn}P_{k-nn,x,y}(t) + W_{TPS}P_{TPS,x,y}(t)$$

Dynamic combination

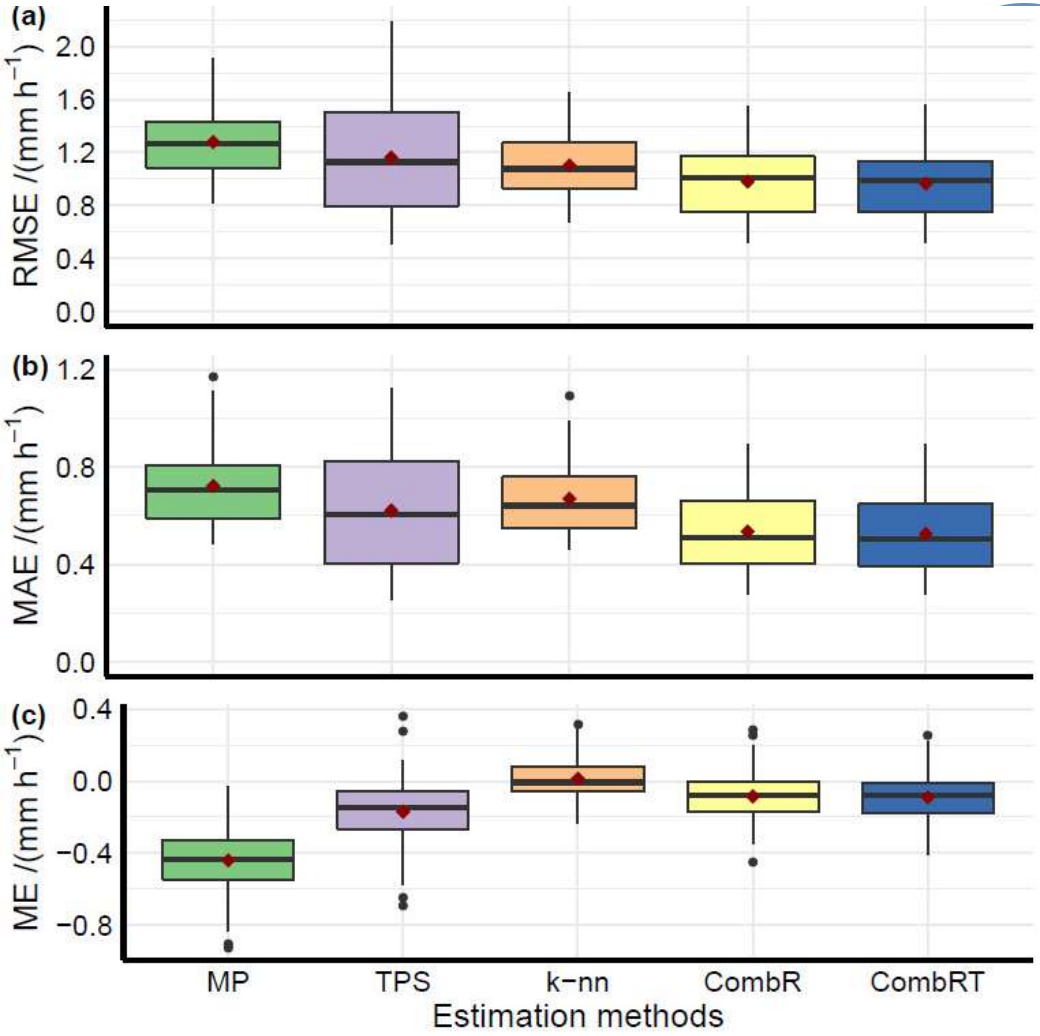
Weight vary with time and space

Identify similar events



Results from the study

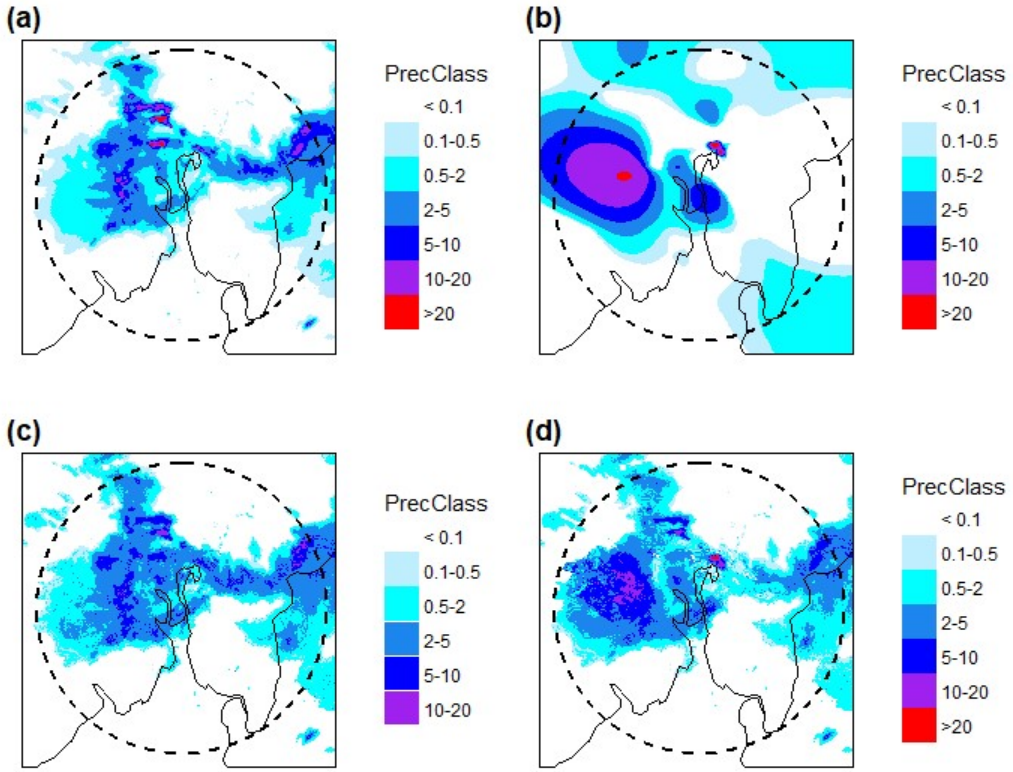
- ✓ 25 % improvement in RMSE compared to original radar precipitation
- ✓ Improved hourly radar-based continuous precipitation field for the study region



Sivasubramaniam et al., (2019)

Radar-based precipitation field

High-intensity summer hourly event
2014.06.26 15:00



(a) Radar (b) TPS (c) k-nn (d) Merged

https://www.aftenposten.no/viten/i/8vWw/Meteorologisk-institutt---Nei-til-druknede-byer

Aftenposten A-magasinet Osloby Sport Meninger Sommertilbud Meny

Nå faller det omtrent 20 prosent mer nedbør over Norge i løpet av et år enn det gjorde for 100 år siden. Infrastrukturen vår må prøve å henge med.

FOTO: Stig B. Hansen

Juni har vært en våt affære både i 2014 og 2015.

Vann så det holdt

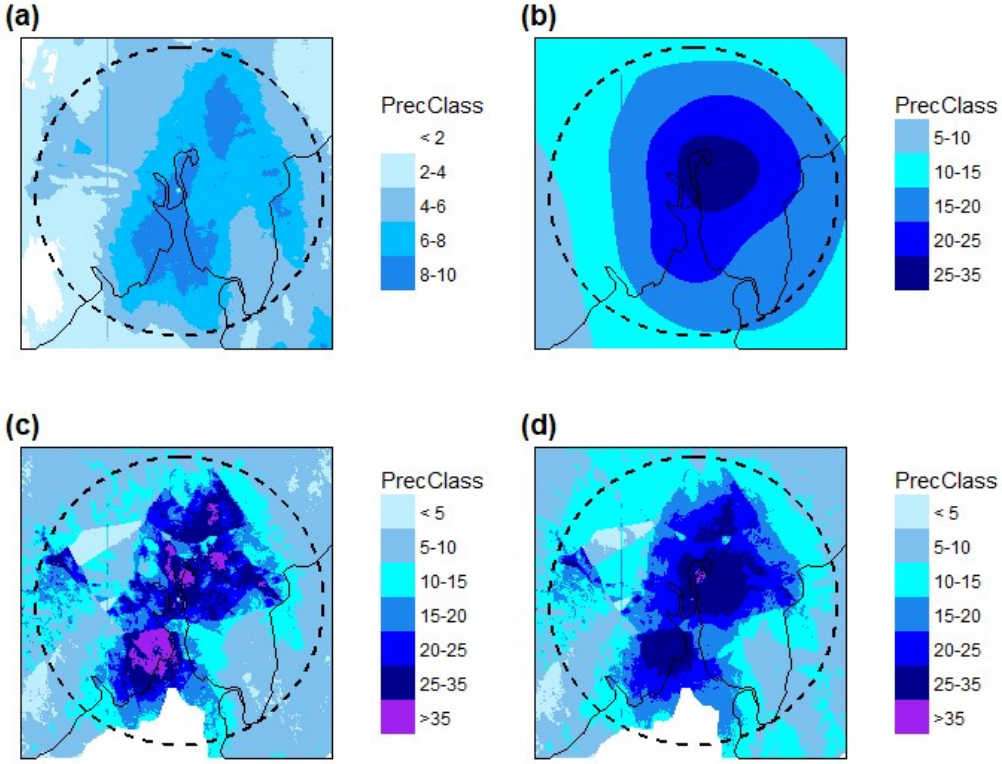
I juni 2014 druknet Oslo. Kumlokkene fôr i været, veier ble oversvømte, biler sto med vann til tenningslåsen og butikker måtte stenge. Målestasjonen på Blindern satte ny rekord, med 46,1 mm regn på bare en time. Dette tilsvarer 46 tusen kubikkmeter regn pr kvadratkilometer. Vi kunne fylt 23 olympiske, 50-meters svømmebasseng med regnet fra den ene kvadratkilometeren.

Det samme døgnet satte vi også døgnnedbørsrekord. Fra den 26. til den 27. juni 2014 kom det 72.8 millimeter nedbør på Blindern.

Radar-based precipitation field

Snow storm 2015.03.26 06:00 -11:00

Accumulated 6-hour event



(a) Radar (b) TPS (c) k-nn (d) Merged

https://www.dagbladet.no/nyheter/snokaos-pa-veiene---stanser-all-busstrafikk/60748045

Snøkaos på veiene - stanser all busstrafikk

Metereologene fikk rett - på god vei mot en halvmeter snø.

KAOS PÅ VEIENE: Bilkø, buss og fotgjenger kjemper mot den våten snøen ved Operatunnelen i Oslo sentrum. Før klokka 08 i dag har Ruter innstilt all busstrafikk i Oslo og omegn - for første gang denne vinteren. FOTO: HALVOR NJERVE/DAGBLADET.

Her må 20-bussen dyttes av passasjerene under snøkaoset i Oslo torsdag morgen.

FOTO: LARS SVENDSEN / PRIVAT

Results from this merging study - published

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Outline

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Thank you for your attention

Questions and Comments are welcomed.

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