Impact of time displaced precipitation estimates for online updated models

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Rain detection for runoff modelling

- **Gauges**: No Movement, no spatial distribution. Accurate.

Rain detection method affect nature of model errors

- GAUGES: Time displacements
- RADAR: Scaling

Best/worse ???
Rain detection for runoff modelling

- **Gauges**: No Movement, no spatial distribution. Accurate.


**Updated online models**

Can not distinguish time shifts from magnitude errors.

Updating: Synchronization issues.

**Objective:**

Compare impact of time displaced rain data with that of scaled rain data for online updated models.
Simplification/assumptions

- **Gauges**: No movement, no spatial distribution. Accurate.

1d setup
Movement = time displacement

RUNOFF
Online storm water model
Online storm water model

With Updating

Analysis Forecast
Forecast error

Time

Model

Radar
Rain gauge
Gauge
Online storm water model

With Updating (rain gauge)
Online storm water model

Model

With Updating (RADAR)

Time
Size of displacements

- **Average** rain cell velocity in northern Europe 10 m/s
- 5 m/s not unusual

![Travel time graph](attachment:image.png)

Time [min] vs Distance [km] for travel at 5 m/s and 10 m/s.
Methodology

True rain

Time displaced rain data

Updated Model

Displaced Forecast

Comparisons

Model

True model states

Biased rain data

Updated Model

Biased Forecast
Rain data

- Precipitation truth

\[ P_{\text{true}} = \text{Svk 28184 (1995 – 2005)} \]

- Displaced rain data (rain gauge)

\[ P_{\text{disp}}(t) = P_{\text{true}}(t - a) \]

- Biased rain

\[ P_{\text{bias}}(t) = c \cdot P_{\text{true}}(t), \quad c = 1 \pm \frac{\text{bias}}{100} \]
Model

- Time Area model
  \[ Q(t) = \frac{A}{Tc} \sum_{i=t-Tc}^{t} P(i) \]

- Observation (true runoff)
  \[ Q_{obs}(t) = \frac{A}{Tc} \sum_{i=t-Tc}^{t} P_{true}(i) \]

- Updated forecast model (x min. forecast)
  \[ Q_x(t) = \frac{A}{Tc} \left( \sum_{i=t-Tc}^{t-x-1} P_{true}(i) + \sum_{i=t-x}^{t} P_f(i) \right), \quad \text{for } x < Tc \]
**Error quantification**

- **Forecast error**

\[
e(t) = Q_{\text{obs}}(t) - Q_x(t) = \frac{A}{T_c} \left( \sum_{i=t-T_c}^{t} P_{\text{true}}(i) - \sum_{i=t-T_c}^{t-x} P_{\text{true}}(i) - \sum_{i=t-x}^{t} P_f(i) \right)
\]

\[
= \frac{A}{T_c} \sum_{t-x}^{t} \left( P_{\text{true}}(i) - P_f(i) \right) \quad \text{for } x < T_c
\]

- **SS_{err}**

\[
\sum_{i=1}^{n} e(i)^2 = \left( \frac{A}{T_c} \right)^2 \sum_{j=1}^{n} \left( \sum_{i=t-x}^{t} (P_{\text{true}}(i) - P_f(i)) \right)^2
\]
**Convenient properties**

- **SS_{err}(disp)/SS_{err}(bias) independent of catchment:**

  \[
  \frac{SS_{err}(disp)}{SS_{err}(bias)} = \frac{\left(\frac{A}{Tc}\right)^2 \sum_{j=1}^{n} \left( \sum_{i=t-x}^{t} (P_{true}(i) - P_{true}(i-a)) \right)^2}{\left(\frac{A}{Tc}\right)^2 \sum_{j=1}^{n} \left( \sum_{i=t-x}^{t} (P_{true}(i) - c \cdot P_f(i)) \right)^2}
  \]

- **Direction of time displacement without importance:**

  \[
  \sum_{n}^{\infty} |a_n - a_{n-c}| = \sum_{n}^{\infty} |a_n - a_{n+c}|
  \]

- **No importance if bias is negative or positive:**

  \[
  \sum_{n}^{\infty} |P - P \cdot 0.90| = \sum_{n}^{\infty} |P - P \cdot 1.10|
  \]
Results

Tc = 40 minutes
Results

\[ \text{SS}_{\text{err}}(\text{disp.}) = \text{SS}_{\text{err}}(\text{bias}) \]

\[ \text{Any } T_c = 40 \text{ minutes} \]
Conclusion

Rain data requirements are different for updated models.

Independent of Tc:

- Frequent updating/short term forecasts:
  - Correct timing essential ->
    - (1) Radar better than gauges.
    - (2) Many bad gauges better than few good gauges.

- Infrequent updating/long forecasts:
  - Accuracy the more important.
Questions?