# 100-m Resolution Urban-Scale Modelling of Extreme Rainfall in Singapore

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## BACKGROUND

Urbanization is favorable for generating localized wind convergence, fostering enhanced convection and heavy rainfall resulted from differential surface heating of the boundary layer between different land covers. CCRS/MSS is developing high resolution urban scale modelling which allows us to provide more detailed weather and climate information to support various user sectors. In this collaborative research project funded by MSS we assess the performance of its urban scale model uSINGV for simulating extreme rainfall in Singapore.

### RESEARCH GAP

- Capturing and resolving localized convergence and convection within urban areas continues to be a challenge, even with the high resolution numerical weather prediction (NWP) models operating at sub-kilometer scales and the increased accessibility of high-performance computing power.

## METHODS

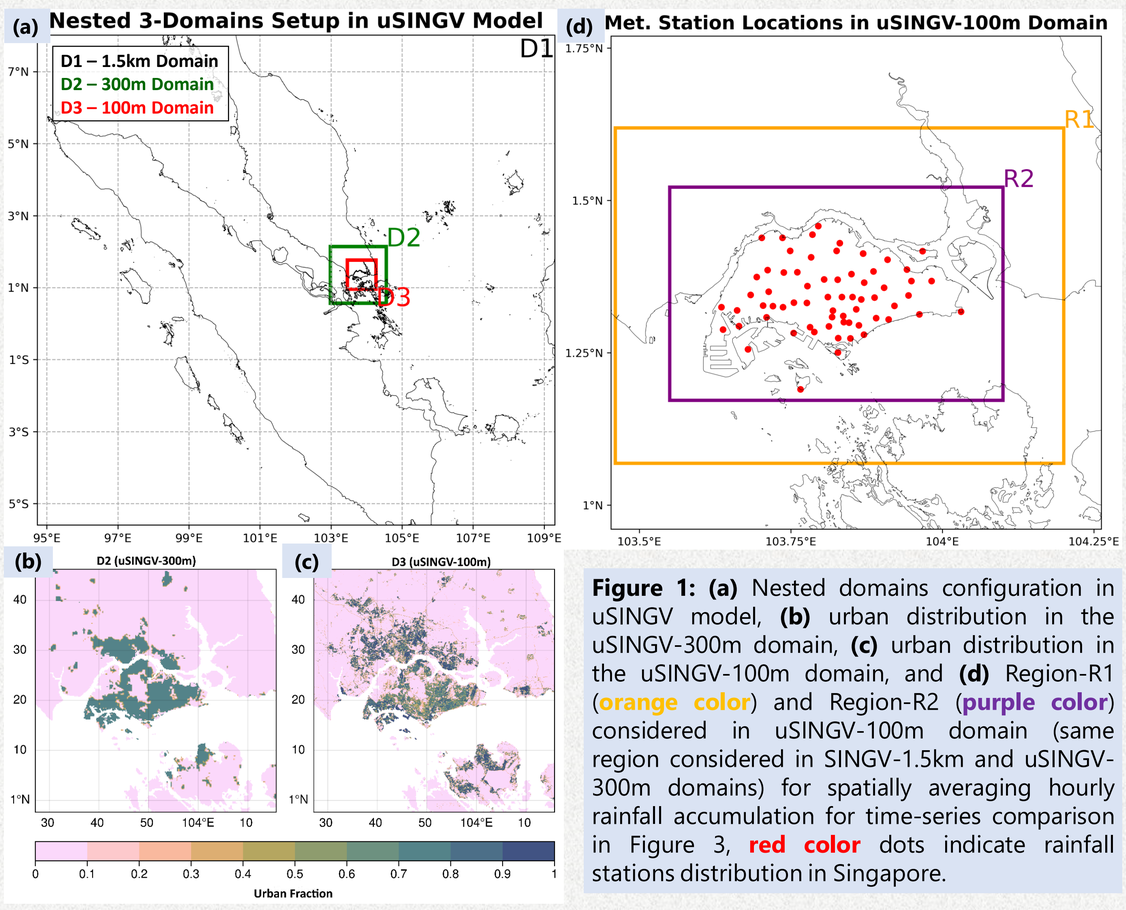



**Figure 1: (a)** Nested domains configuration in uSINGV model, **(b)** urban distribution in the uSINGV-300m domain, **(c)** urban distribution in the uSINGV-100m domain, and **(d)** Region-R1 (**orange color**) and Region-R2 (**purple color**) considered in uSINGV-100m domain (same region considered in SINGV-1.5km and uSINGV-300m domains) for spatially averaging hourly rainfall accumulation for time-series comparison in Figure 3, **red color** dots indicate rainfall stations distribution in Singapore.

- **uSINGV model** (customized version of the UK-Met office's Unified Model for Singapore) with three nested domains setup (Figure 1a) has been used.
- 80 vertical levels are used up to 38.5 km height above surface in the model. **ECMWF Analysis** data has been used as initial and lateral boundary conditions to drive SINGV-1.5km.
- Regional Atmosphere and Land **[RAL3]** physics configuration has been used. Anthropogenic heat flux is not considered.
- 65 rainfall meteorological stations (Figure 1d) have been used for model comparison purpose.
- **Localized wind convergence case** of **01-April-2023** has been analyzed in the present work which resulted into afternoon **[17:00 – 19:00 LT]** extreme rainfall (MSS: rainfall accumulation ≥70 mm/h or ≥35 mm/30 min.) in Singapore.

## CONCLUSIONS

- The case study demonstrates that the 100-meter resolution uSINGV model is skillful for simulating extreme rainfall over Singapore. Nonetheless, further research with more extreme rainfall cases is needed to assess its accuracy in predicting heavy rainfall and convective weather.
- Additionally, this study highlights the advantages of utilizing a sub-kilometer model for modelling surface wind and temperature.

## AIM

- As a case study, assessing how effectively the 100-meter resolution uSINGV urban model simulates extreme rainfall resulting from localized convergence during the afternoon over urbanized areas in Singapore.

## FINDINGS

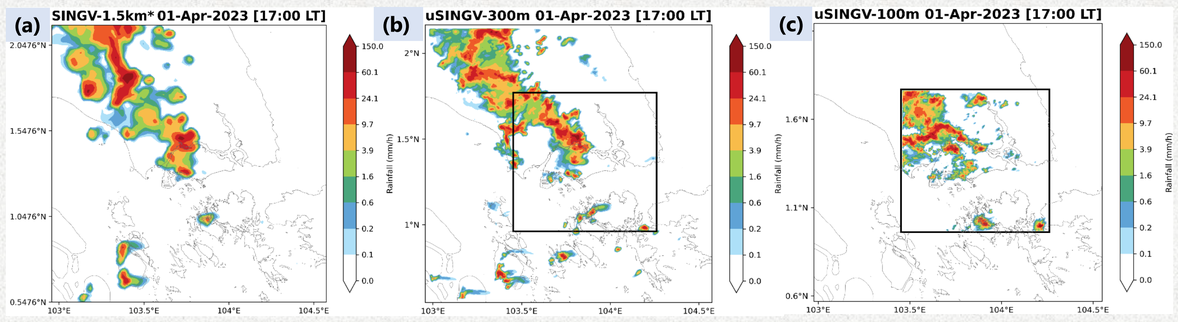
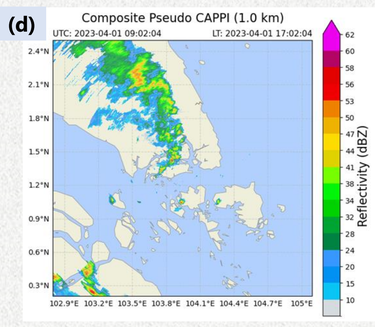



**Figure 2:** Contour plots of hourly rainfall accumulation at 17:00 LT (local time) in **(a)** SINGV-1.5km domain (Zoom-IN), **(b)** uSINGV-300m domain (black box indicates region covered by uSINGV-100m domain), **(c)** uSINGV-100m domain (black rectangular box), and **(d)** Composite Pseudo CAPPI radar image at 1.0 km height on 01-Apr-2023 at 17:00 LT.




- The RAL3 physics configuration with double moment CASIM cloud microphysics scheme in uSINGV has shown improvement in capturing the organized convection and rainfall features in terms of spatial patterns (Figure 2).
- The rainfall onset timings have also improved significantly when compared with the observations (Figure 3), with some underprediction in rainfall rate. The uSINGV-100m domain shown improvement in Region-R2.
- uSINGV-300m and uSINGV-100m both are better than SINGV-1.5km in terms of 10-m wind speed and 1.5-m temperature prediction especially at Changi meteorological station (Figure 4a-4d).

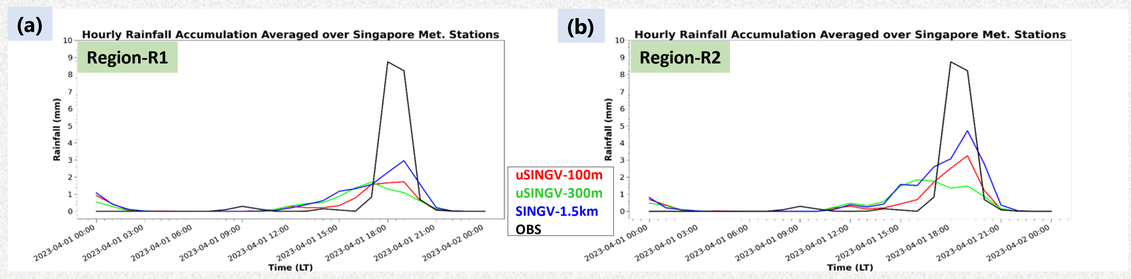



**Figure 3:** Time-series of averaged hourly rainfall accumulation over **(a)** Region-R1, and **(b)** Region-R2 considered as shown in Figure 1d and its comparison with 65 rainfall meteorological station average in Singapore in SINGV-1.5km, uSINGV-300m, and uSINGV-100m domains on 01-Apr-2023.

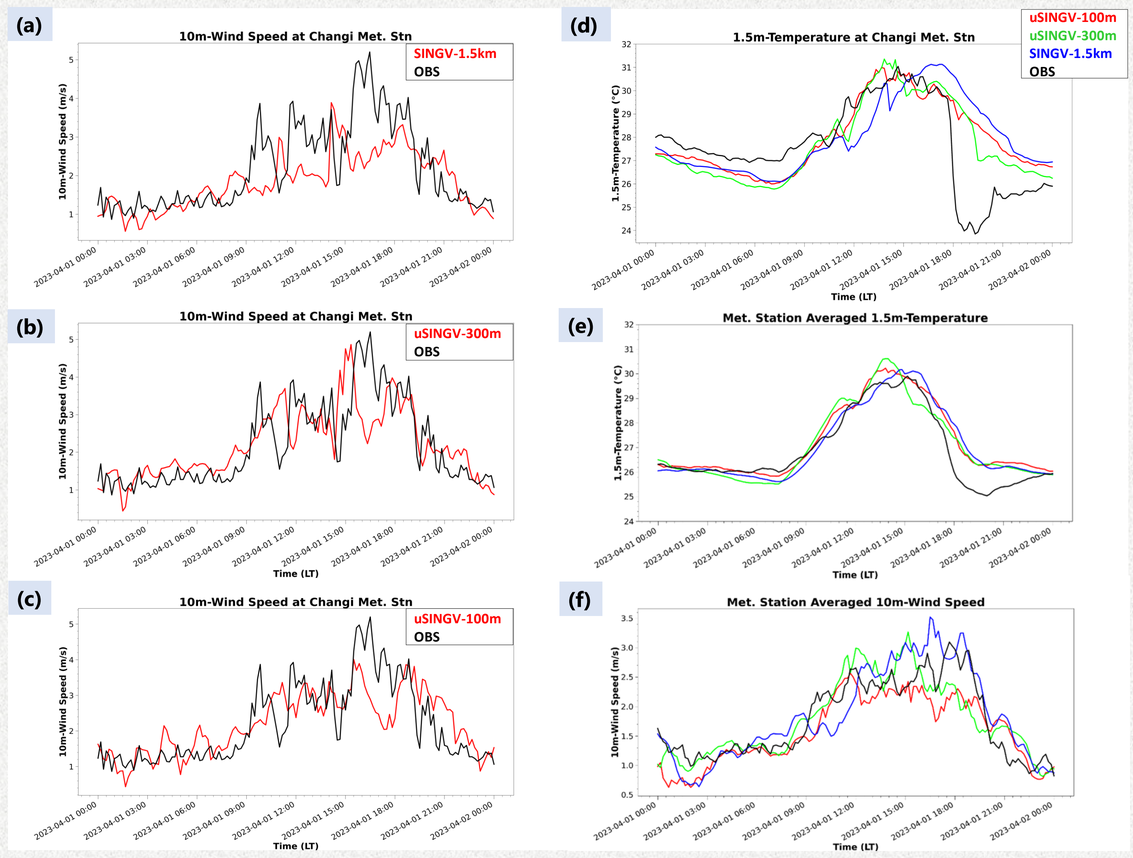



**Figure 4:** Time-series of 10m-wind speed in **(a)** SINGV-1.5km domain, **(b)** uSINGV-300m domain, and **(c)** uSINGV-100m domain on 01-Apr-2023 at Changi meteorological station; **(d)** time-series of 1.5m-air temperature at Changi meteorological station, **(e)** averaged (over 18 AWS) time-series of 1.5m-air temperature, and **(f)** averaged (over 18 AWS) time-series of 10m-wind speed on 01-Apr-2023.

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