Sensibility of rainfall simulation to model horizontal grid spacing: impact of complex terrain and shallow convection parameterization

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Introduction: Réunion Island

- A tropical island in the Indian Ocean
- Steep orography, highest mountain with height of over 3000m
- World record of daily rainfall (1825mm / 24H)
Introduction: Extreme rainfall on 27-30 Jan 2011

- A depression located to the south-west of Réunion
- Intense rainfall (>600mm/4days) in the northern urban area
- One victim, disruptions in traffic and electricity services
Plan

1. Impacts of model horizontal resolutions (4km 2km 1km 500m)

2. Impacts of shallow convection parametrization

3. Resolution of the orography dataset

4. Conclusion
1. Resolution : Model configuration

- French non-hydrostatic mesoscale atmospheric model (MESO-NH)
- Initialization at 00H, 27 Jan 2011
- Coupled with analyses (Aladin) every 6 hours
- Running for 4 days

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EDKF : A shallow convection scheme combining eddy diffusivity transfers and mass flux transfers (Pergaud et al. 2009)
1. Resolution: Total rainfall during the 4 days

4km and 2km runs:
- Large position errors of intense rainfall
- Underestimation of rainfall on the northern coast

Improved simulations in 1km and 500m runs
1. Resolution : Performances evaluated by raingauges

Performances (Coefficient of Variation of the RMSD and Coefficient Correlation) as a function of models resolution and time intervals.

CVRMSD : Average error / mean observation (lower is better)
Correlation : (higher is better)

- Improvements in 48H- and 24H-rain by reducing the grid spacing
- No significant difference between 1km and 500m runs
- Obstacle to simulating rainfalls with interval less than 24H
1. Resolution: $\theta$ and wind at 950hpa

1km and 500m runs
- Opposite wind in the lower level leads to convergences
- Cold pool (induced by evaporation and melting) lifting the moist air triggers deep convection in the coastal area
2. Impact of Shallow Convection: EDKF

- **2km**: No improvement by EDKF, even worse in the coastal area (Ventilation removing moisture in the boundary layer inhibits deep convections).

- **1km**: Enforcing the intense rain by using EDKF.

- **500m**: No significant difference.
2. Impact of Shallow Convection : EDKF

Performance of simulations for 24H-rainfall as a function as model configuration (SC : with EDKF)
3. Impacts of orographic resolution

Interpolation of the orography data from 2km to 1km

Comparison of these simulations:

- Improved simulation even using degraded 1km orographic data compared to the 2km run
- Enforcing the intense rain by real 1km orographic data

(a) 2km (2km topo.)  (b) 1km (1km topo. from 2km)  (c) 1km (1km topo.)
4. Conclusion

- Resolving explicitly the dynamics and physics of atmosphere at 1km resolution is essential to simulate the daily rainfall during this extreme event.

- The impact of shallow convection scheme is highly resolution dependent. There is no significant improvement in rain simulation by using the EDKF.

- The detailed orographic features at 1 km have also impact on the intensity of extreme rain.

Thank you for your attention