A Comparison Between Two Microphysical Schemes of Different Sophistication Levels: Precipitation Downscaling in Complex Terrain on the West Coast of Norway

Bjerknes Centre for Climate Research

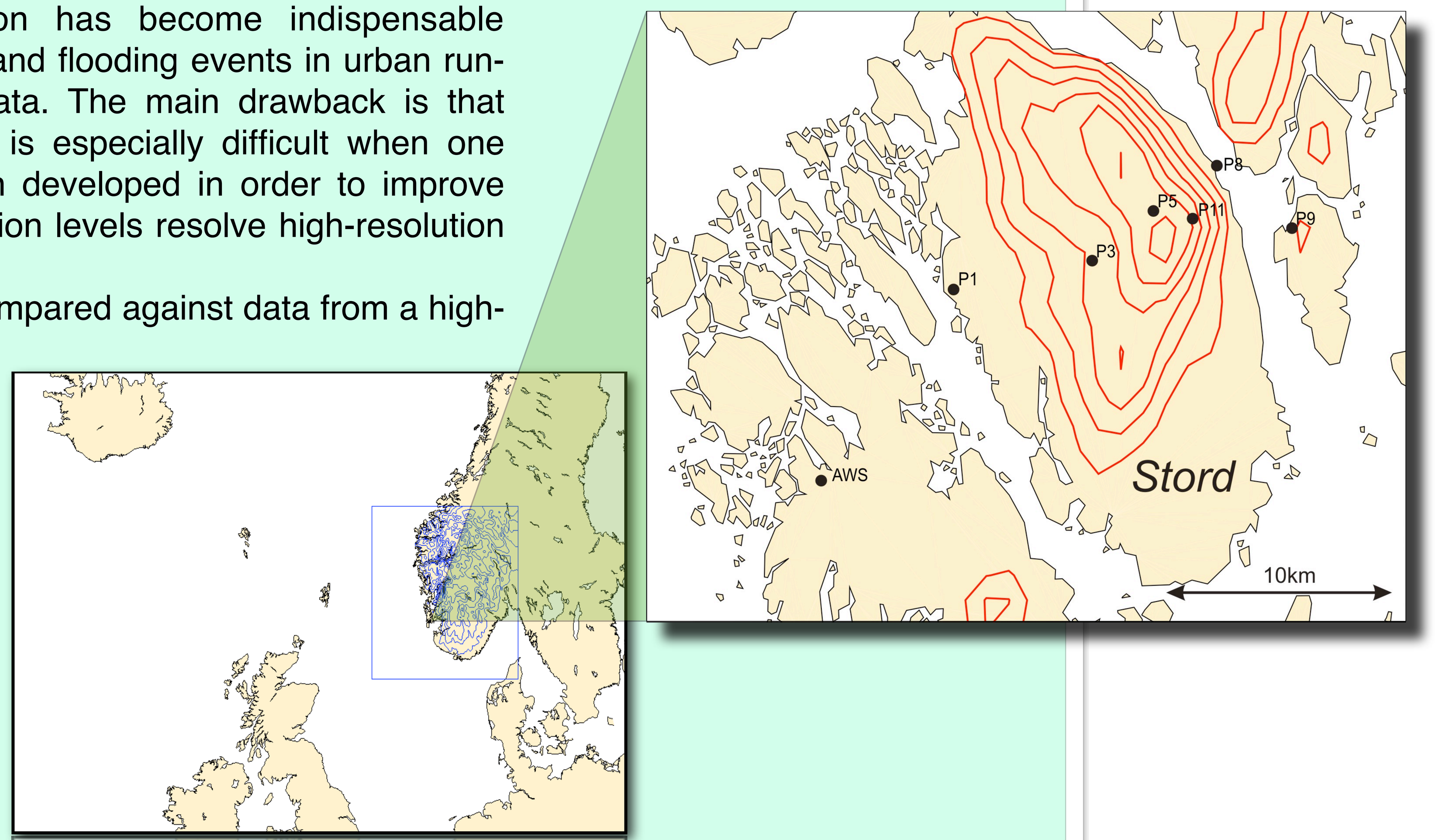
Michel d. S. Mesquita[1,*], Ulla Heikkilä[1] and Idar Barstad[1]

[[1]Allegaten 55, NO-5007 Bergen, Norway; *michel.mesquita@bjerknes.uib.no]

1. Abstract

High-temporally resolved precipitation information has become indispensable nowadays. Emergency planning, mitigation efforts and flooding events in urban run-off water systems are just a few examples of the importance of such data. The main drawback is that precipitation is not always well resolved by climate/weather models. This is especially difficult when one considers complex terrain. A number of microphysical schemes have been developed in order to improve precipitation. How well do the microphysical schemes of different sophistication levels resolve high-resolution precipitation information in complex terrain?

Results from the Weather Research and Forecasting modeling system are compared against data from a high-frequency (10 min) precipitation observational network. The network is concentrated on a mountainous area on the west coast of Norway. The density of the network is comparable to a model grid spacing of approximately 3km. The data analysis focuses on a 3-month period (Sep-Nov 2005). Two different microphysical schemes representing different sophistication levels have been tested. The results from the model comparison and verification are presented with respect to different accumulation periods and wind directions.



2. Experiment Setup

- Location: Stord, a Norwegian island (20km NS x 10km WE), 600m mountain
- STOPEX I campaign (Autumn 2005) (STOPEX; Reuder et al. (2007)
- Numerical Model WRFV3.0 (www.wrf-model.org): 2-way nested domains (10km-3.3km); boundaries orchestrated by the ECMWF-analysis; 40 vertical levels
- 2 microphysical schemes: "mp3", a simple 3-class scheme (Hong et al. 2004); "mp10", a more sophisticated multi-class scheme (Morrison and Pinto, 2006)
- FDDA-nudging with 6-hour relaxation time

3. Changes in different accumulation periods?

STOPEX I (SON 05) Station / Measure	Wet (%) - 10 min (mp3/mp10)	Wet (%) - 1 hr (mp3/mp10)	Wet (%) - 3 hr (mp3/mp10)	Wet (%) - 24 hr (mp3/mp10)	Total accum. (mm) (mp3/mp10/obs)
P1 upwind-flat land	525/443	283/252	200/189	122/122	787/729/333
P3 upwind-slope	360/311	215/200	156/150	115/113	927/766/768
P5 top	307/266	199/185	149/143	105/102	927/766/1120
P11 leeside-top	284/234	169/152	130/123	100/100	864/700/1220
P8 leeside-slope	357/286	224/199	170/161	116/116	856/676/838
P9 leeside-flat land	362/289	220/194	167/159	113/116	804/634/640

Table 1 - Simulated precipitation across Stord island (autumn 2005). Wet events (i.e.: 100% means as observed) for various accumulation periods (columns 2-5) and total accumulated amounts during the campaign (last column). "mp3" and "mp10" refer to two different microphysical schemes used. Underlined values indicate the ones with better skill. Note: this table shows the sensitivity of the accumulation intervals for evaluation of models (Barstad and Smith, 2005).

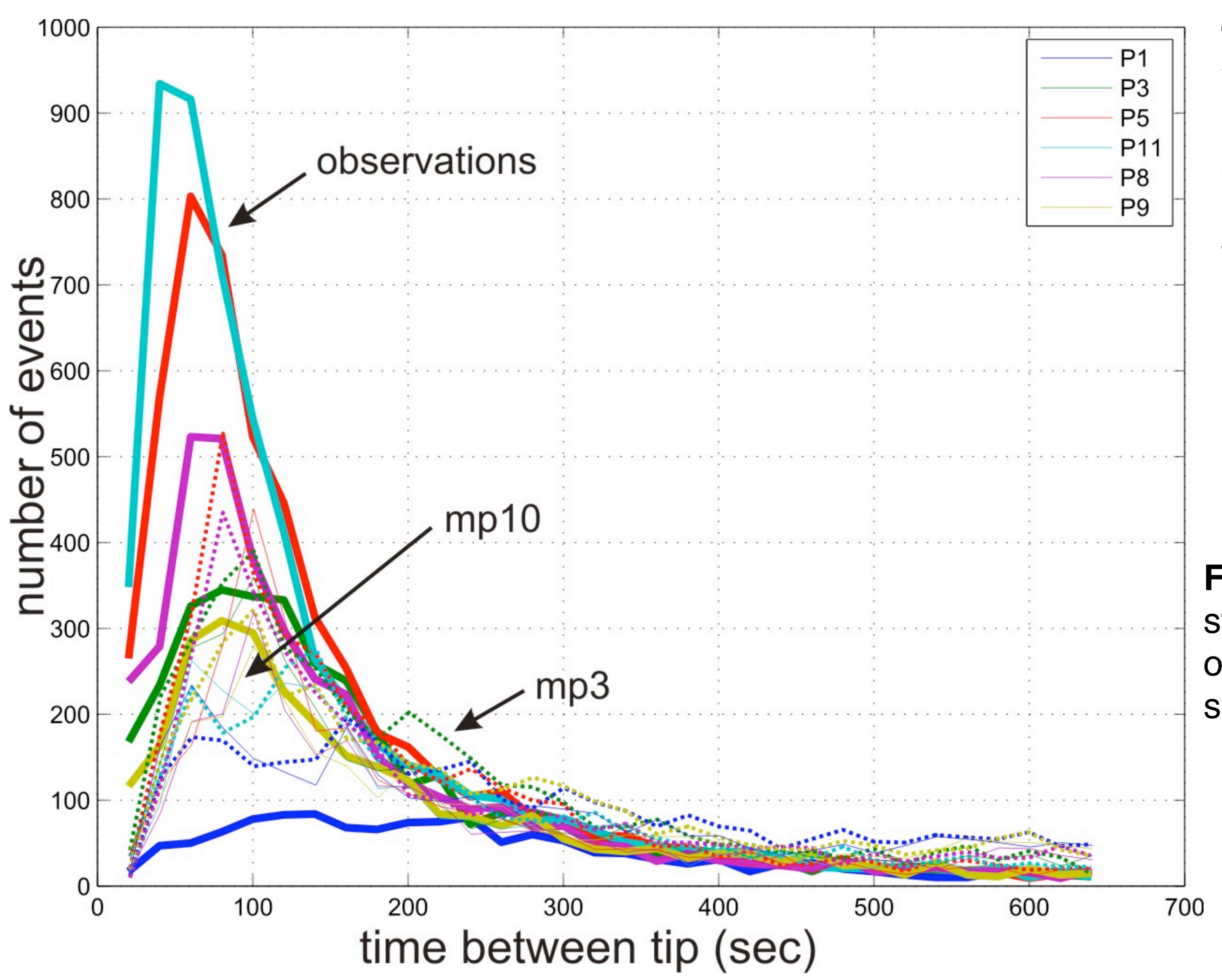


Figure 1 - Tipping-bucket vs. modelled values for STOPEX I. 6 stations are shown, c.f. Table 1. Heavy solid lines represent the observations, dotted lines the mp3-simulation, and thin lines the mp10-simulation.

4. What about wind direction?

Example ➟ Wind (200-270°)

STOPEX I — mp3 | mp10

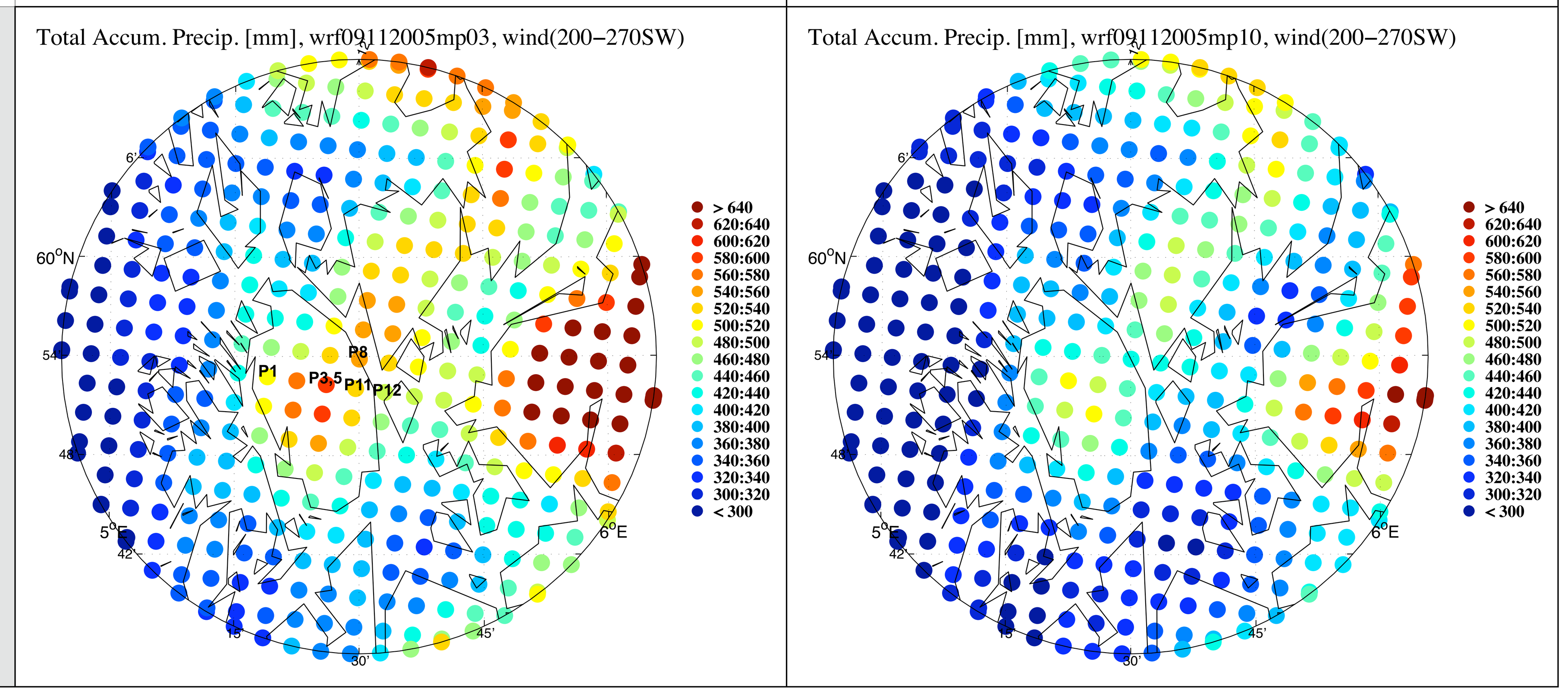


Figure 2 - Total accumulated precipitation, from WRF runs, for when the wind direction was between 200 and 270°. Plots are shown for the STOPEX I and for the microphysical schemes "mp3" and "mp10". Stations names, as seen by WRF, are located in the first plot.

	Accumulated Precipitation (mm)			
Wind Direction ➟	150-200°	200-270°	270-300°	All directions
Station / Measure	(mp3/mp10/obs)	(mp3/mp10/obs)	(mp3/mp10/obs)	(mp3/mp10/obs)
P1 upwind-flat land	124/122/45	501/452/224	65/80/25	787/729/333
P3 upwind-slope	190/164/122	581/486/446	66/61/60	927/766/768
P5 top	190/164/161	581/486/692	66/61/95	927/766/1120
P11 leeside-top	190/155/166	531/444/783	65/57/106	864/700/1220
P8 leeside-slope	169/130/107	546/437/514	63/57/77	856/676/838
P9 leeside-flat land	172/139/90	492/406/385	73/48/59	804/634/640

Table 2 - Simulated precipitation across Stord island (autumn 2005 - STOPEX I). Accumulated precipitation (mm) for various wind directions (columns 2-4) and total accumulated amounts during the campaign (last column). "mp3" and "mp10" refer to two different microphysical schemes used. Underlined values indicate the ones with better skill. P3 and P5 are seen as the same point in WRF (Fig.2).

5. Concluding Remarks

- Simulation by a mesoscale model with 3.3km grid spacing has similar problems as the standard problem for numerical models: it rains too often and too little
- The simpler scheme performs better in complex terrain, except on flat land
- The "mp10" scheme performs well for the main wind directions with most precipitation. For other directions (270-300°), convection is involved and in those cases, "mp3" performs better
- A case study having higher resolution (not shown) indicates that higher intensities (15-20% increase) are expected if a 1km grid is nested inside a 3km one
- Similar results (not shown) were obtained for the STOPEX II campaign during autumn 2006

References

Barstad, I. and R. B. Smith, 2005: Evaluation of an Orographic Precipitation Model. Journal of hydrometeorology **6**, 85-99.
Hong, S.-Y., J. Dudhia, and S.-H. Chen, 2004: A Revised Approach to Ice Microphysical Processes for the Bulk Parameterization of Clouds and Precipitation. Mon. Wea. Rev. **132**,103–120.
Morrison, H., and J. O. Pinto, 2006: Intercomparison of bulk microphysics schemes in mesoscale simulations of springtime Arctic mixed-phase stratiform clouds. Mon. Wea. Rev. **134**, 1880–1900.
Reuder, J., I. Barstad, G.O. Fagerlid and A.D. Sandvik, 2007: Stord Orographic Precipitation Experiment (STOPEX): An overview of phase I. Hydrology and Earth System Sciences **10**, 17-23.

Acknowledgements

We would like to thank the WRF developers for making their code freely available. We also thank the Bjerknes Centre for Climate Research for funding this research. Special thanks to Tor de Lange, Joachim Reuder, Geir Ottar Fagerlid, Marianne S. Andersen and Eli Anne Ersdal who made invaluable contributions in the observational data acquisition.