High-Resolution Simulations of a Heavy Precipitation Event Over the Australian Snowy Mountains: The Role of Microphysics

Artur Gevorgyan[1],
Luis Ackermann[1], Yi Huang[2], Steven Siems[1], Michael Manton[1]

1-School of Earth, Atmosphere and Environment, Monash University
2-The University of Melbourne

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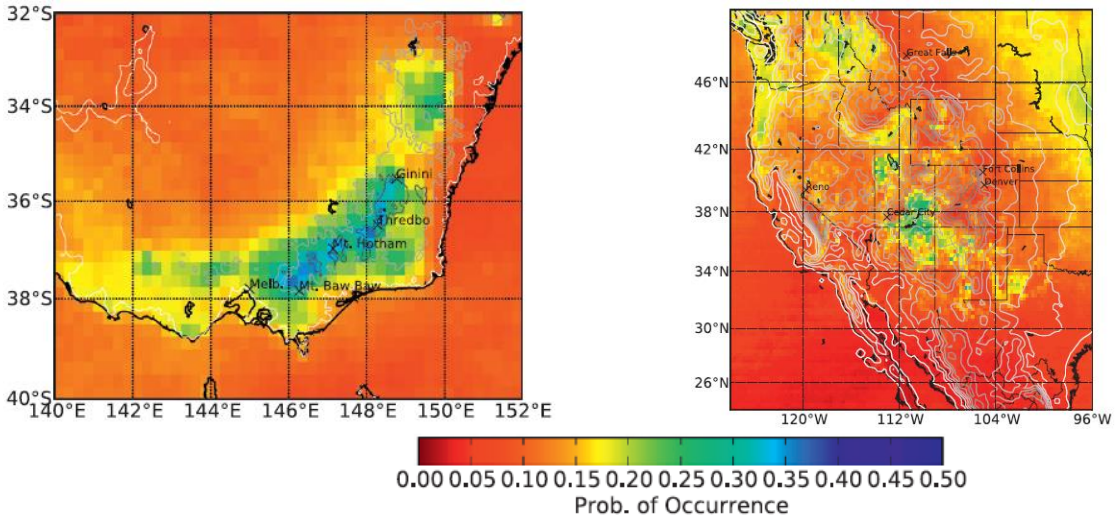
Motivation of this study

- Precipitation over the Snowy Mountains accounts for 29% of annual mean inflows to the Murray-Darling Basin. The water is used for hydroelectricity under a pumped-hydro framework.
- In-situ and satellite observations find much higher concentrations of super-cooled liquid water for wintertime orographic clouds over Southeast Australia than those of the Western U.S. (Morrison *et al.,* 2013, JAMC)



Probability of MODIS observing a supercooled pixel over southeastern Australia(left) and the western continental United States (right) during 2005–2009 winter seasons, (Morrison *et al.,* 2013, JAMC)

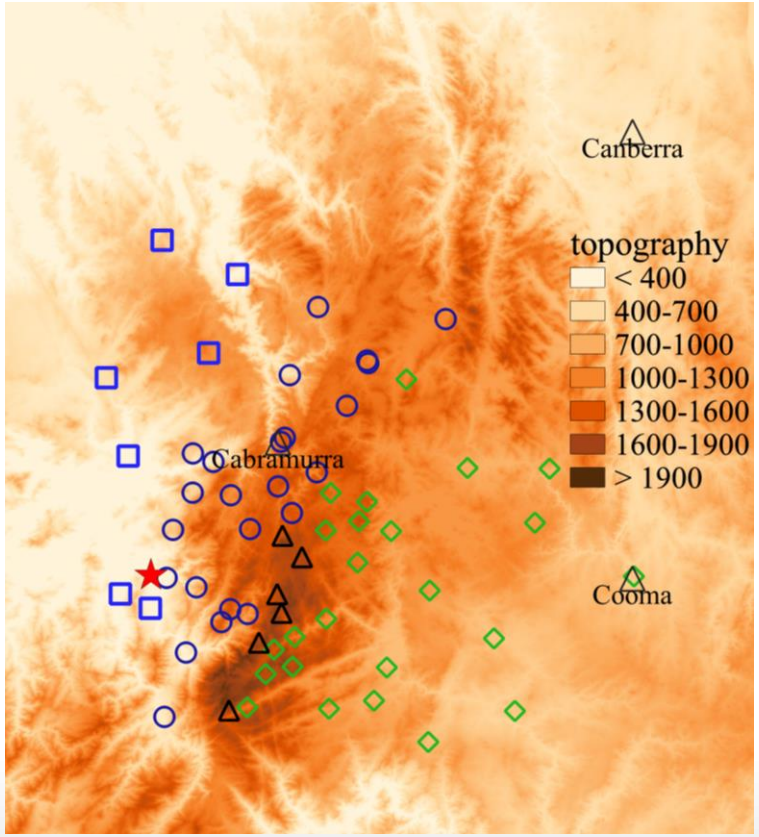
- The distribution of simulated wintertime orographic precipitation over the Snowy Mountains was biased in the WRF model, potentially due to the microphysics of SLW and mixed phase clouds in (Sarmadi et al., 2019, *Atmospheric Research*)

Meteorological observations over the Snowy Mountains during the campaign, 2018. **Cabramurra** is the main observation location (MRR, Doppler Radar, Parsivel Disdrometer, Microwave Radiometer).

Session 4 - Preliminary Results from Recent Field Campaigns 4.1 - Characteristics and Processes of Wintertime Precipitation over the Australian Alps, Luis Ackermann

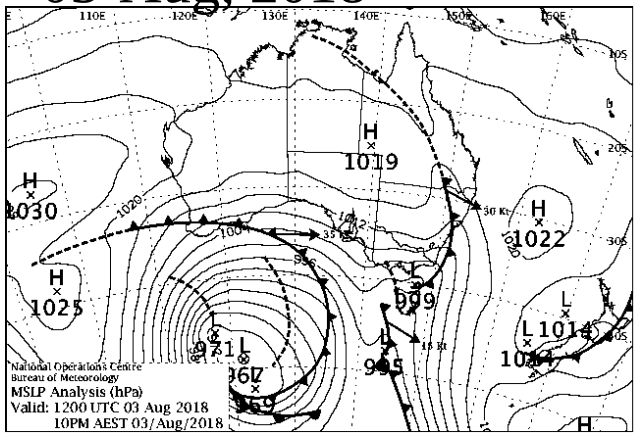
upwind windward

top leeward

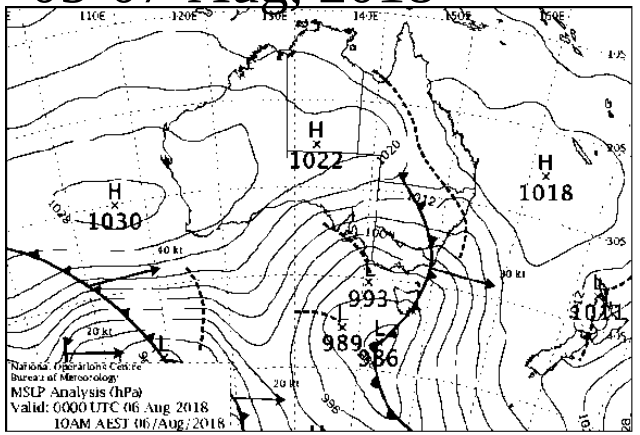


Selected case studies of cold front passages over the Snowy Mountains

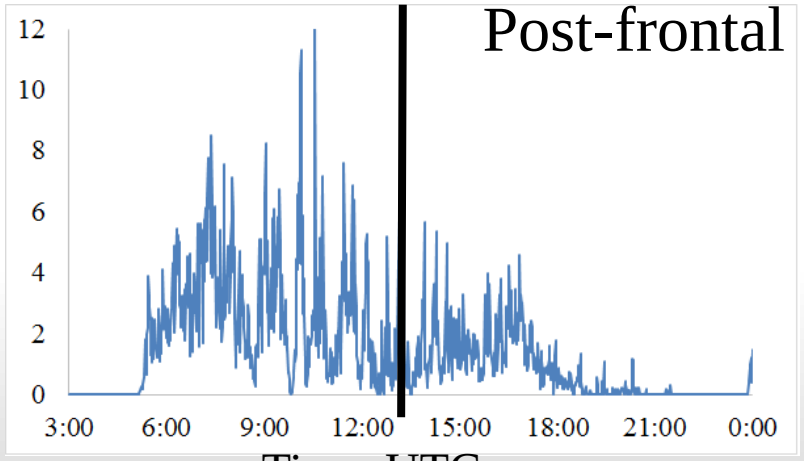
03-Aug, 2018

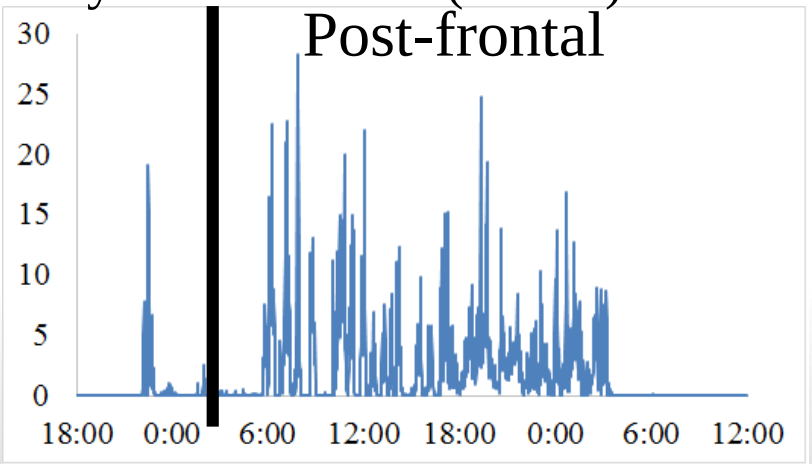


05-07-Aug, 2018



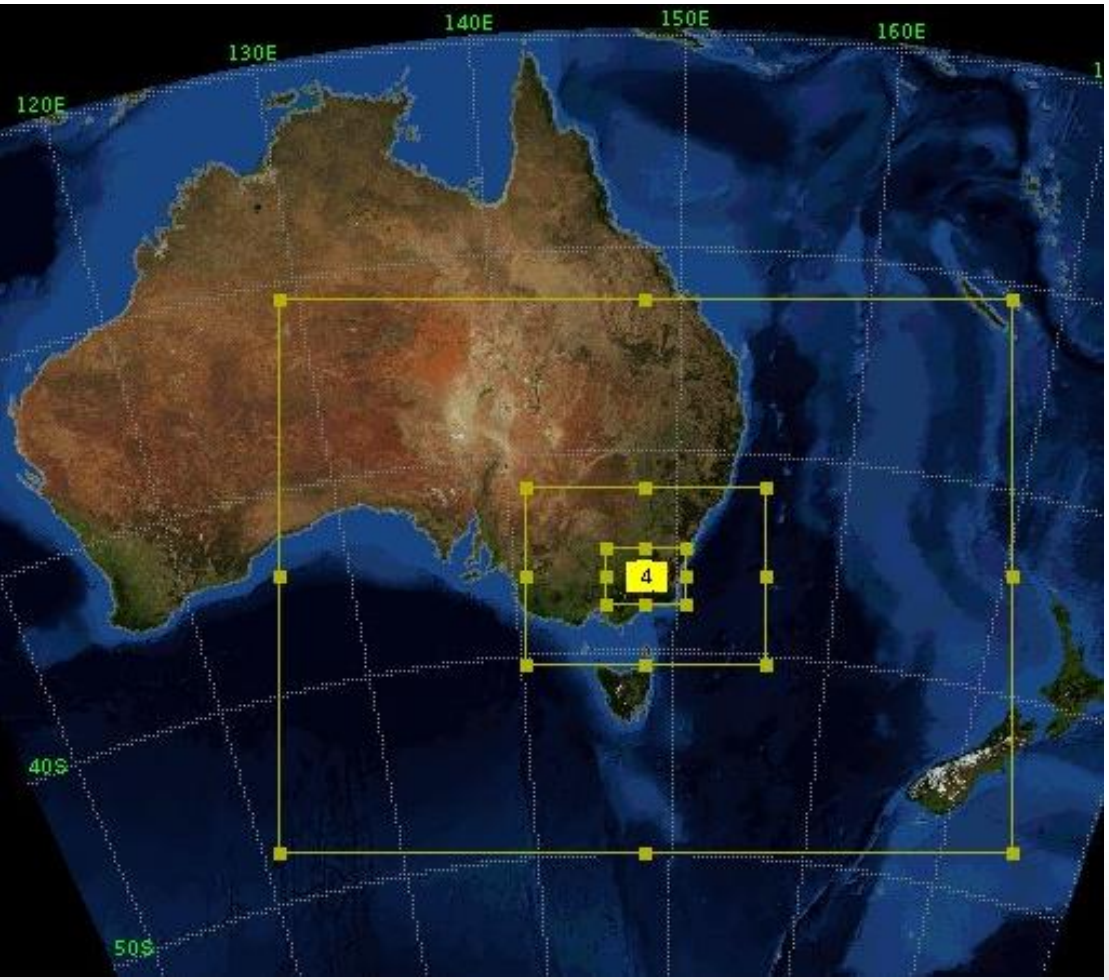
1-min observed precipitation intensity at Cabramurra (mm/hr)

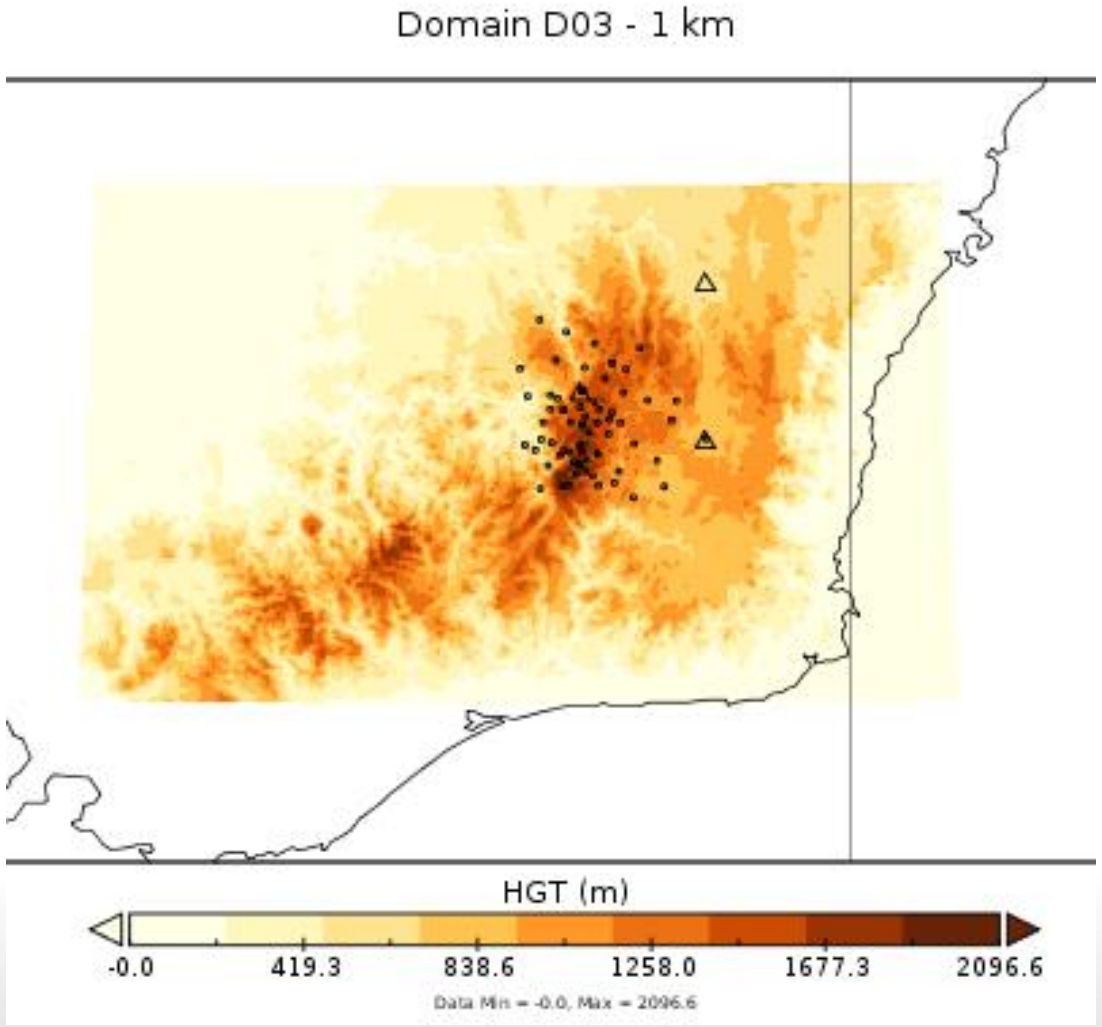




WRF model domain configuration setup

- Triple downscaling: 9 km – 3 km – 1 km using 3:1 parent grid ratio (D04 - 333 m is planned to run),
- D01 490x370, D02 478x358, **D03 466x346 (1 km domain)**

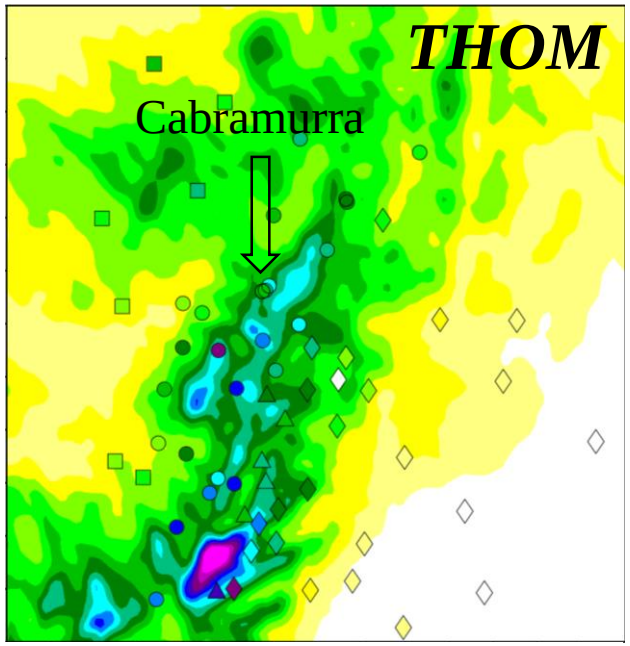


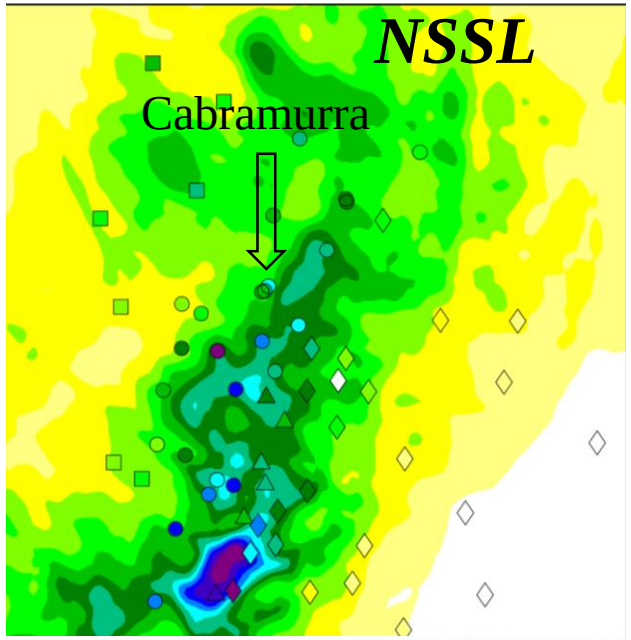


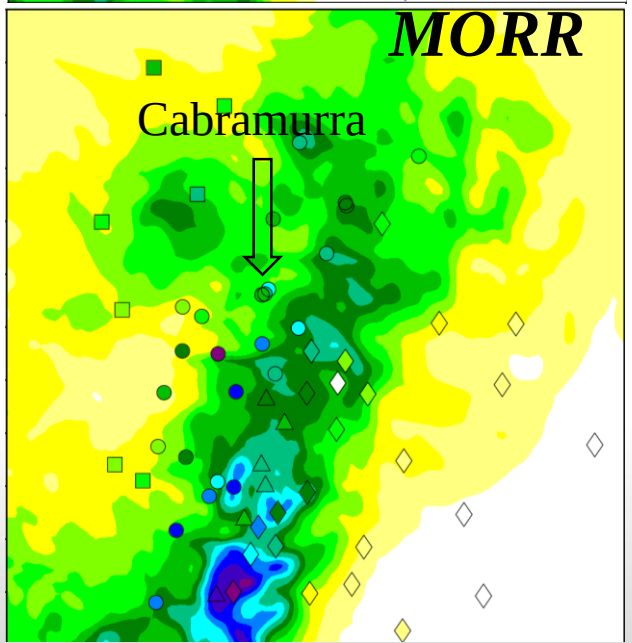
WRF V4.2: Sensitivity experiments

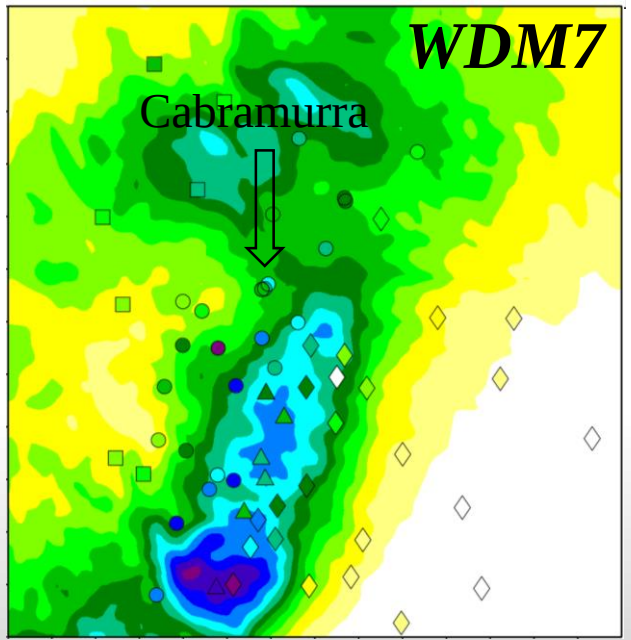
Parametrization	THOM	NSSL	MORR	WDM7
Microphysics	mp_physics=28 Qc Qr Qi Qs Qg Ni Nr Nwf Nif Thompson (2014) Scheme, Aerosol-Aware	mp_physics=17 Qc Qr Qi Qs Qg Qh Nc Nr Ni Ns Ng Nh NSSL 2-mom Scheme	mp_physics=10 Qc Qr Qi Qs Qg Nr Ni Ns Ng Morrison	mp_physics=26 Qv Qc Qr Qi Qs Qg Qh Nc, Nr WDM7, 2018
PBL	Cumulus	Land/Sea surface	Short wave radiation	Long wave radiation
pbl_physics=2 MYJ PBL scheme;	**cu_physics=2** (d01 only) Betts-Miller-Janic	**surface_phys=4** Noah-MP	**ra_sw=1** Dudhia Scheme	**ra_lw=4** RRTMG Scheme
Initial and lateral-boundary conditions	ECMWF HRES Operational model data with ~ 9 km (0.08x0.08 deg. grid) spatial resolution and 137 vertical model levels derived from the ECMWF MARS archive, one-hourly update for lateral-boundary conditions			

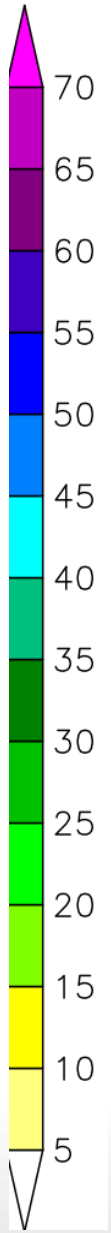
Observed and simulated total precipitation amount for 03-Aug-2018 case dominated by prefrontal precipitation: Sensitivity to cloud microphysics



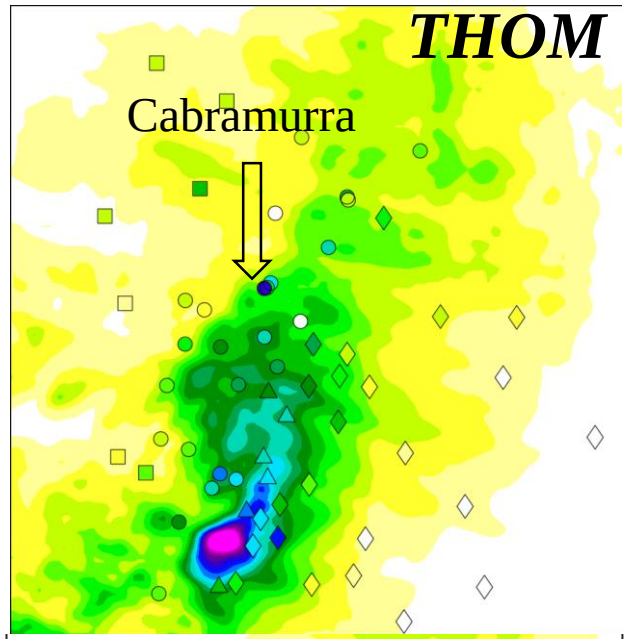


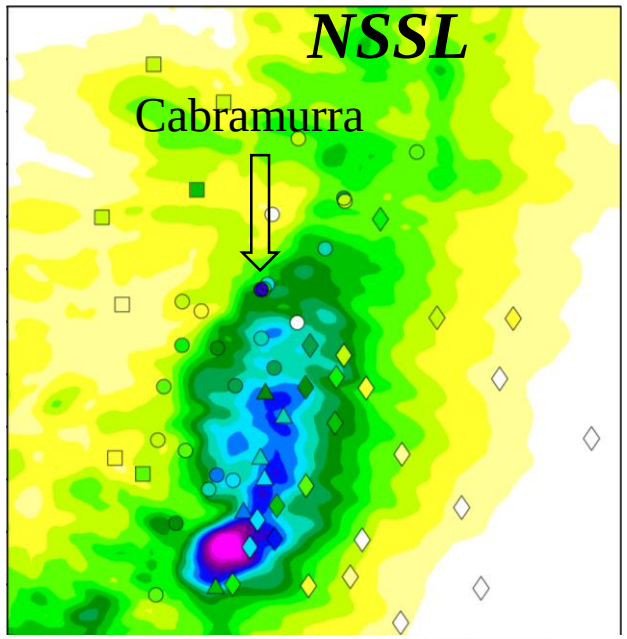


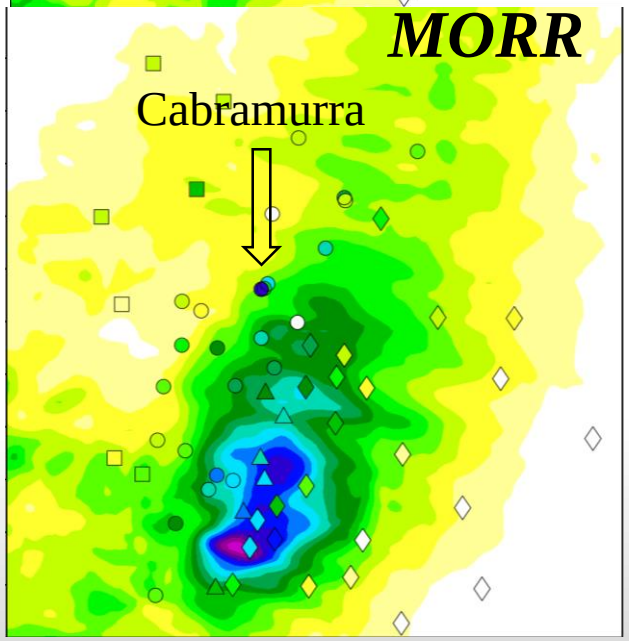


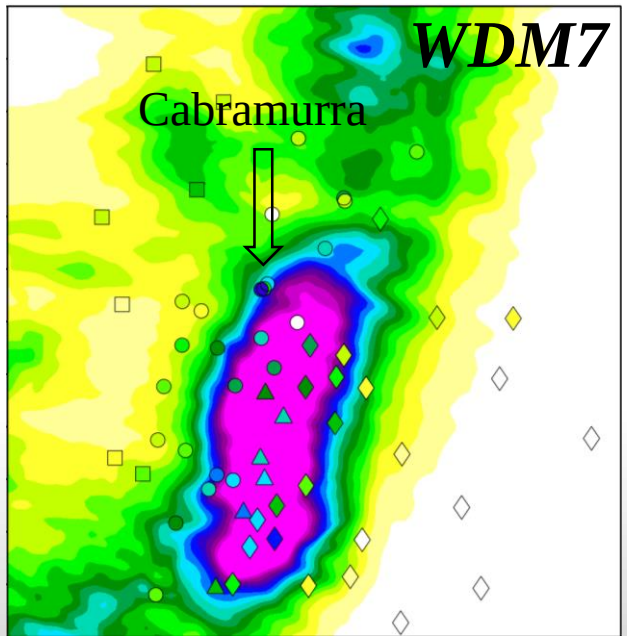


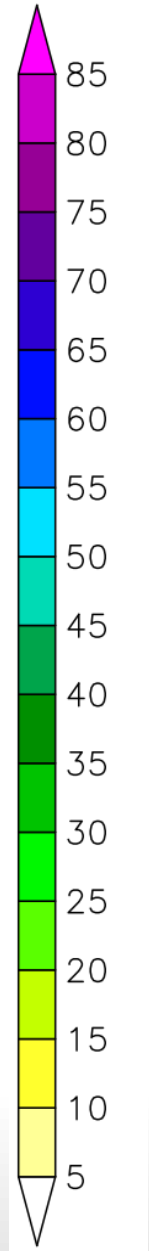
Observed and simulated total precipitation amount for 05-Aug - 07-Aug 2018 case dominated by post-frontal precipitation: Sensitivity to cloud microphysics







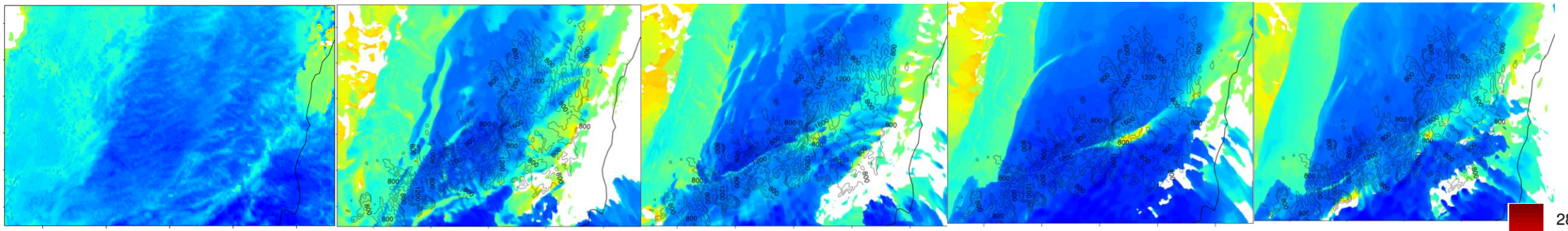




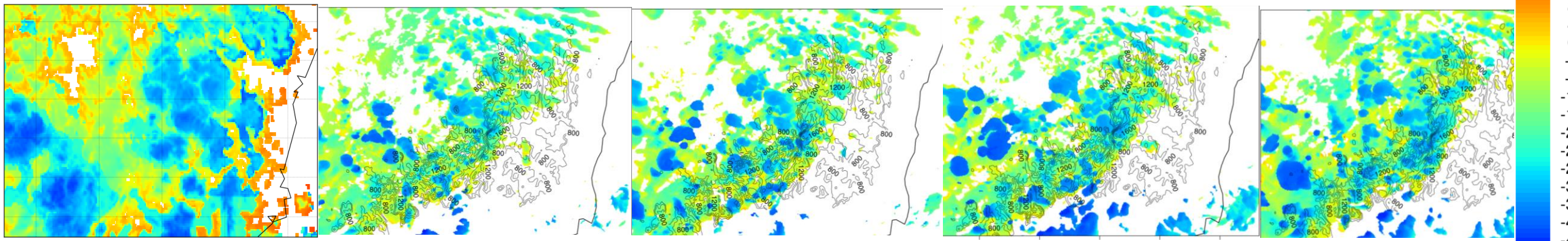
Observed (Himawari-8) and simulated cloud-top temperatures over the Snowy Mountains:

0800 UTC, 03-Aug, 2018 – cold-front cloud band

Himawari-8 | THOM | NSSL | MORR | WDM7



0700 UTC, 06-Aug, 2018 – post-frontal convective clouds



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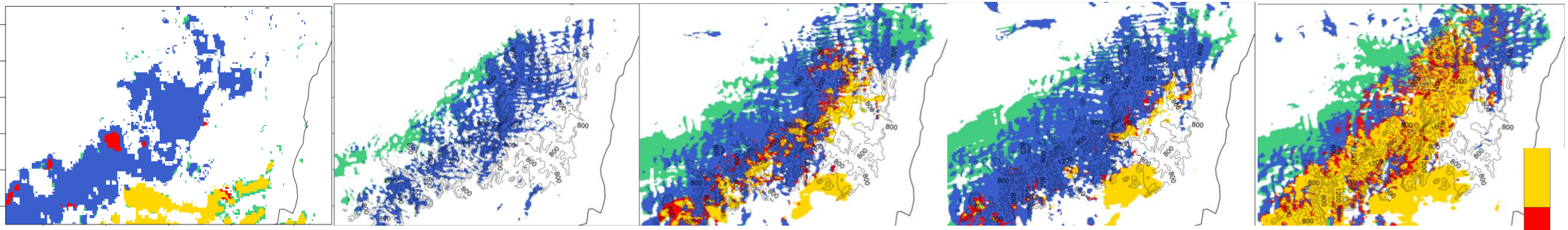
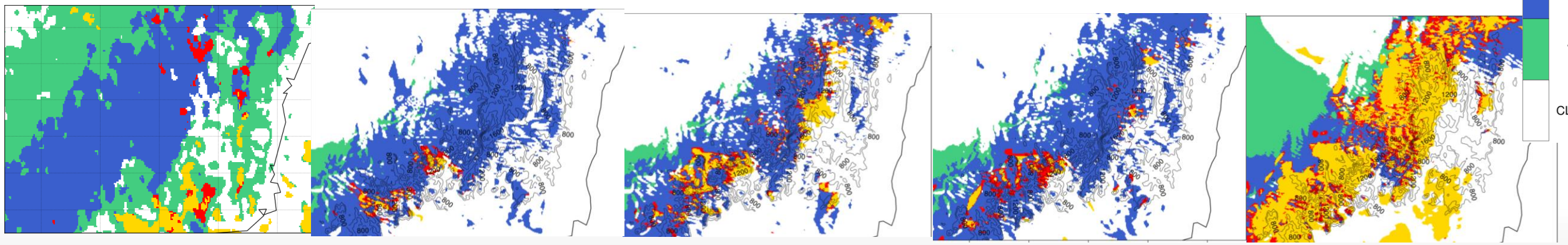
Simulation of post-frontal supercooled liquid water clouds (SLW) over the Snowy Mountains comparing observed (Himawari-8) and simulated cloud-top phases

1600 UTC, 03-Aug, 2018

Himawari-8 | THOM | NSSL | MORR | WDM7

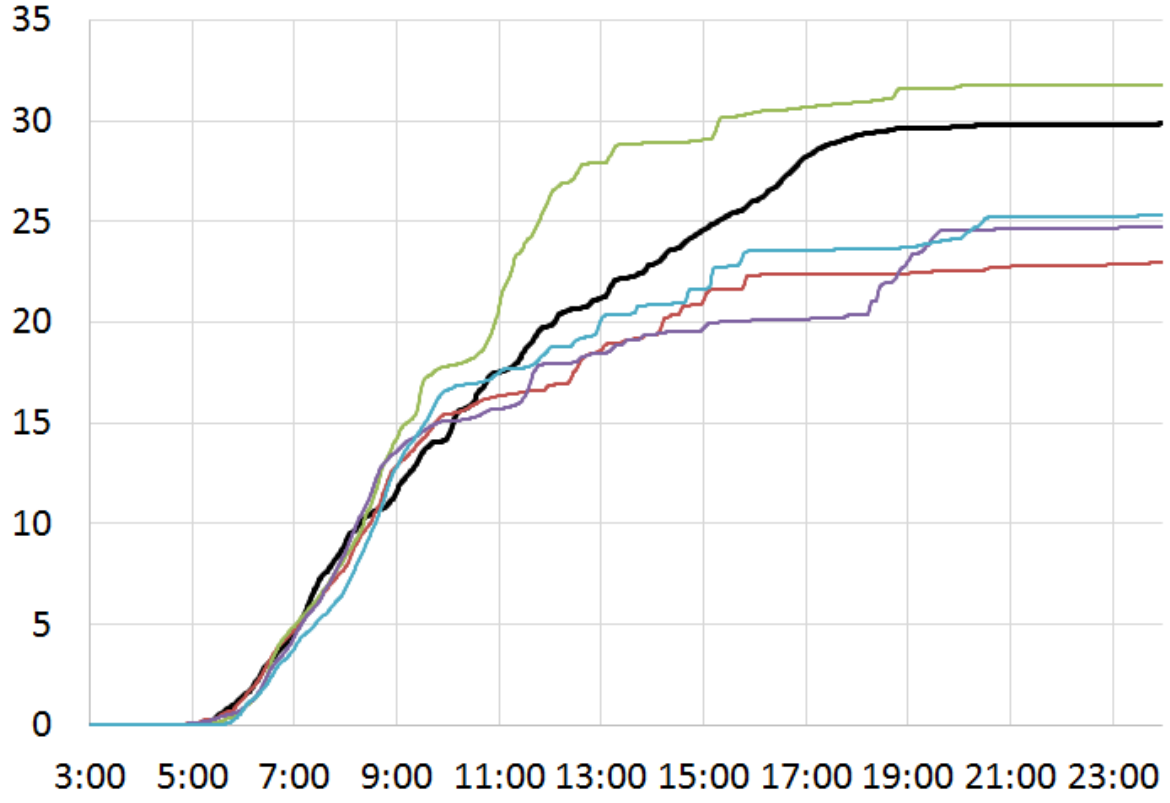


0100 UTC, 07-Aug, 2018

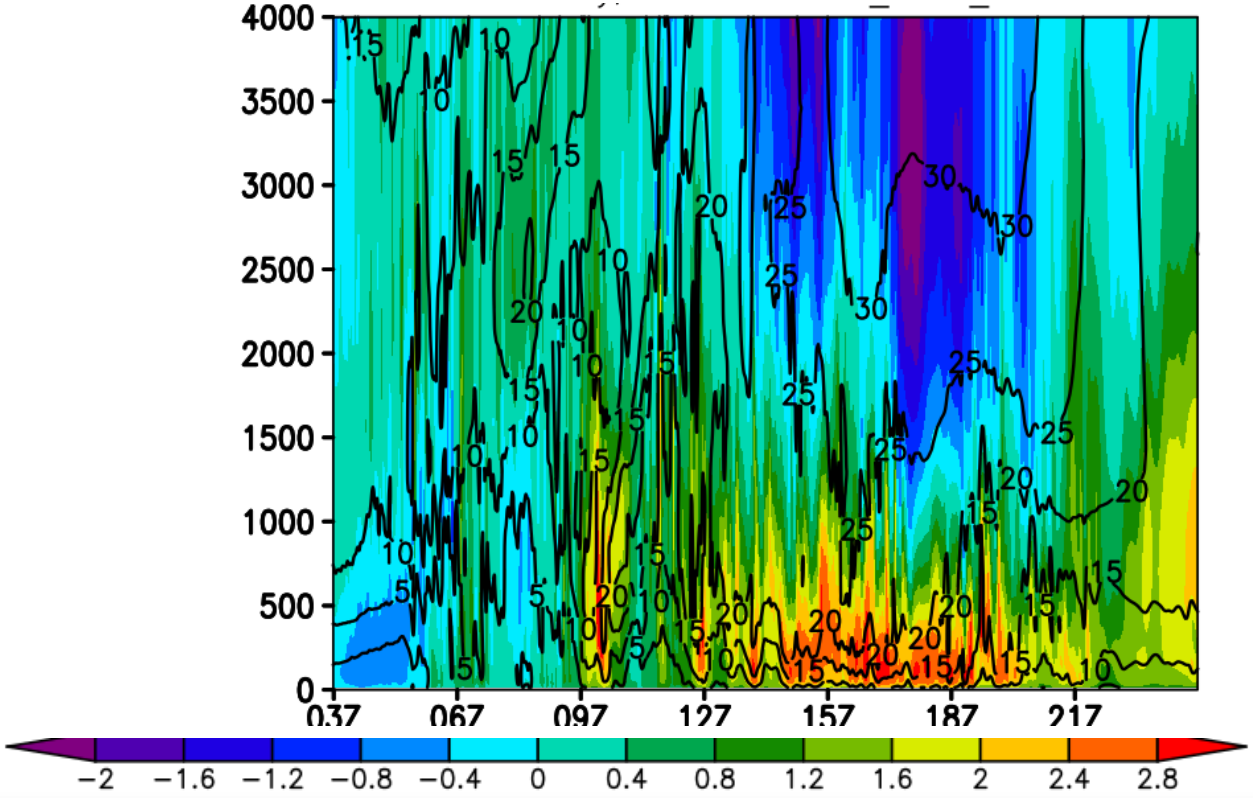


Simulation of precipitation amount, wind and low-level orographic uplift at Cabramurra: 03-Aug, 2018

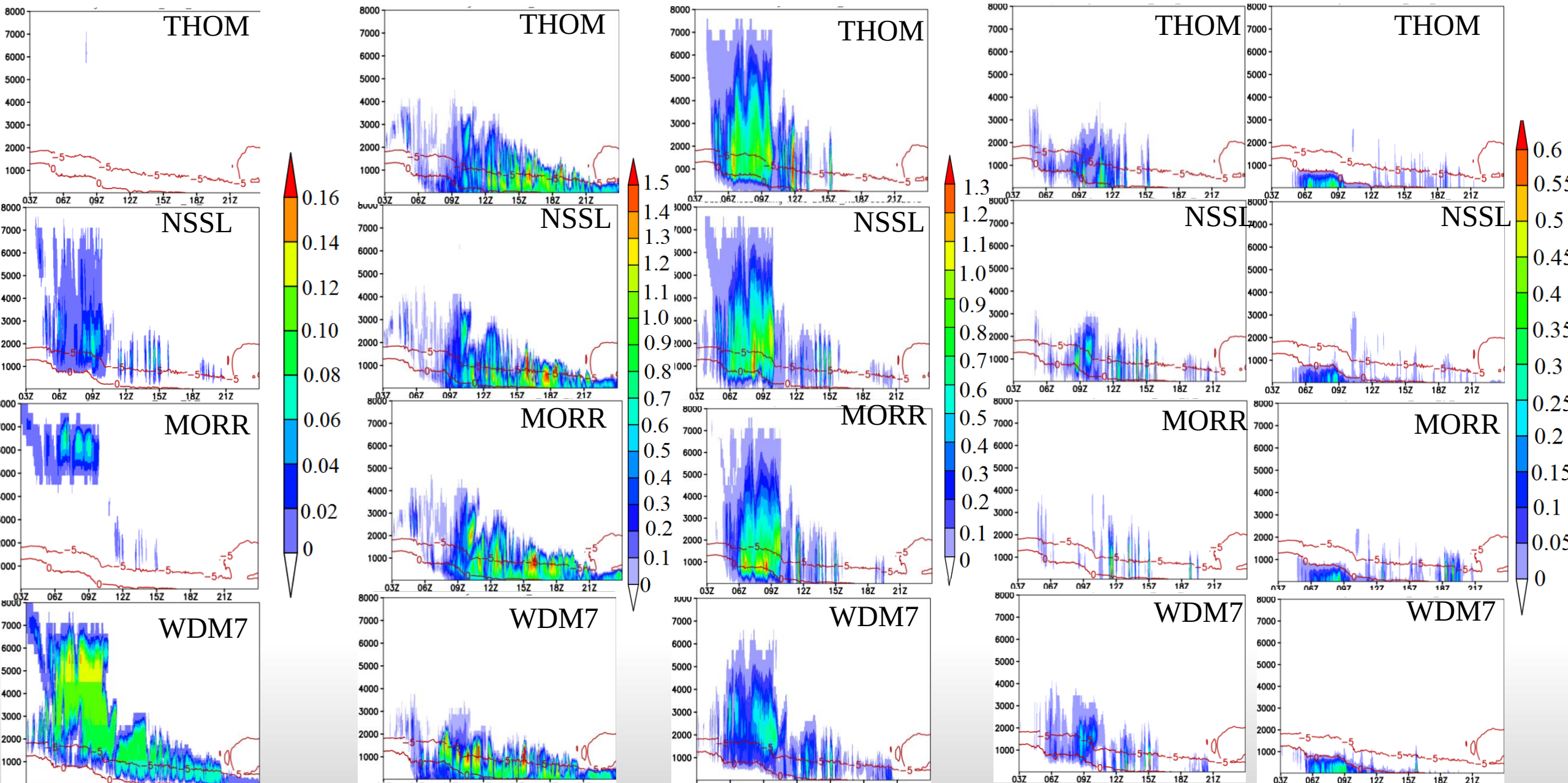
1-min observed and simulated accumulated precipitation (mm)



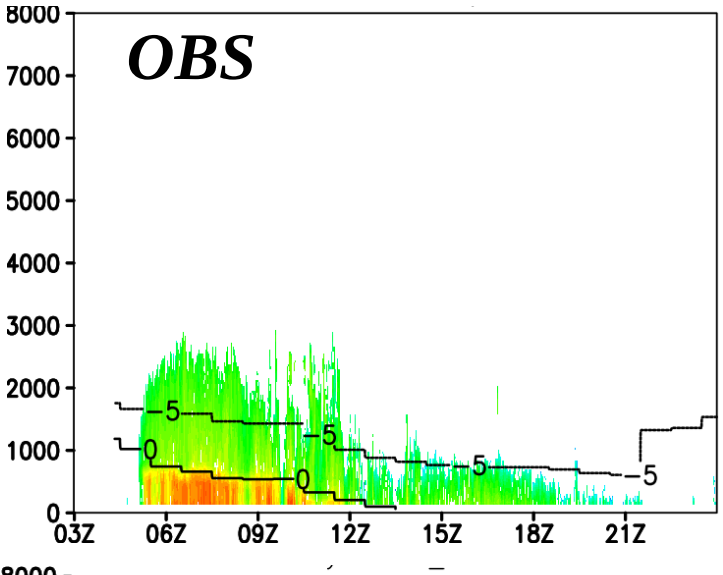
Time-height cross-section of vertical velocity (shaded) and u-wind (cross-barrier) component (contours) at Cabramurra, THOM run

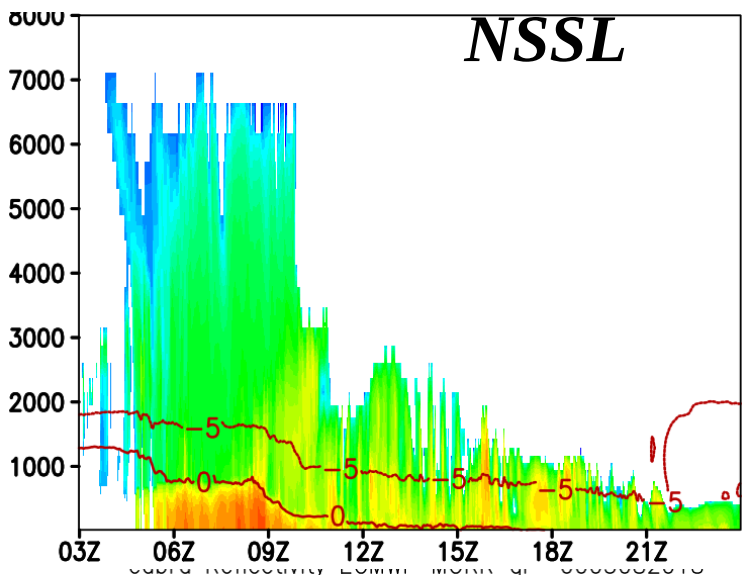


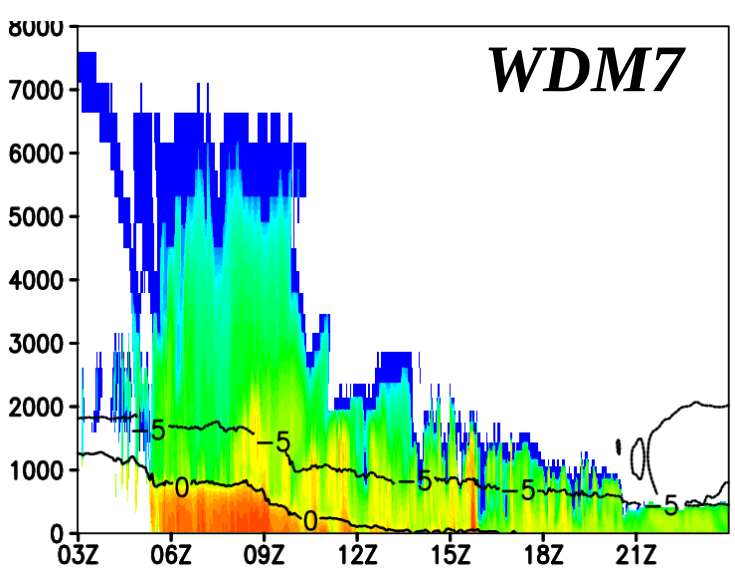
Simulated time-height cross-sections of hydrometeor species (g kg^{-1}) at Cabramurra for 03-Aug, 2018 case

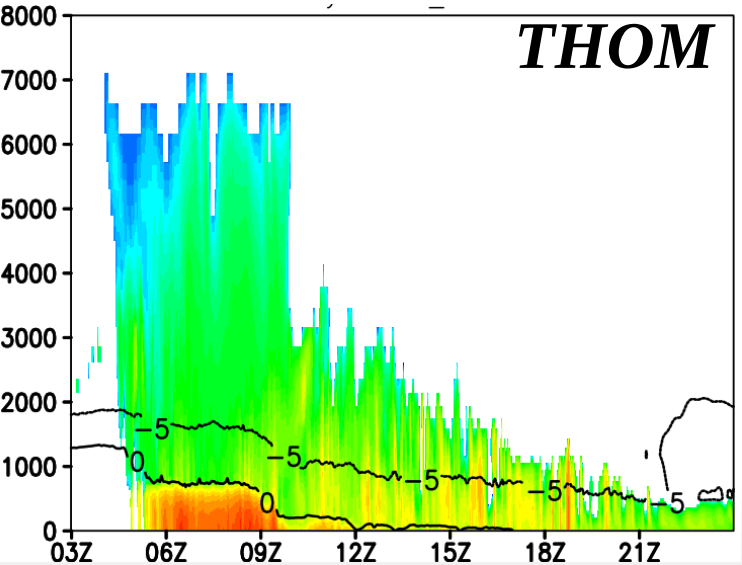


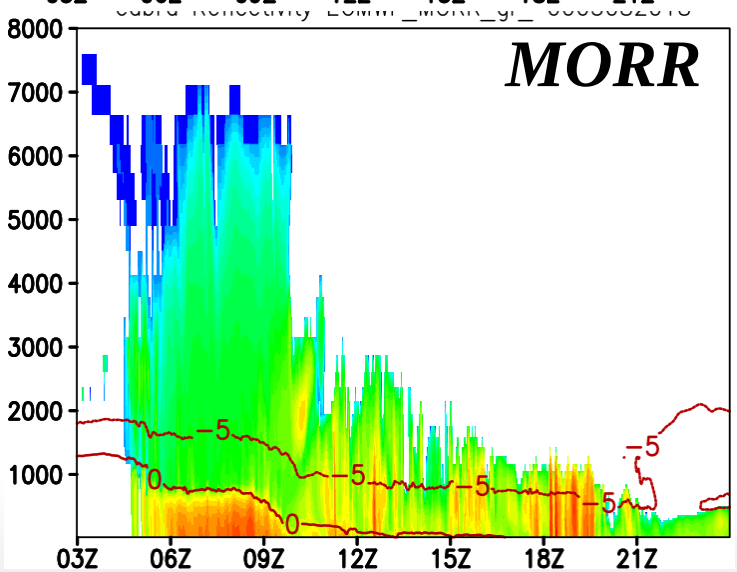
Simulated and observed equivalent reflectivity at Cabramurra for 03-Aug 2018 case: Micro Rain Radar operates at 24 GHz, while the WRF simulations are from Quick beam radar simulator at 35 GHz

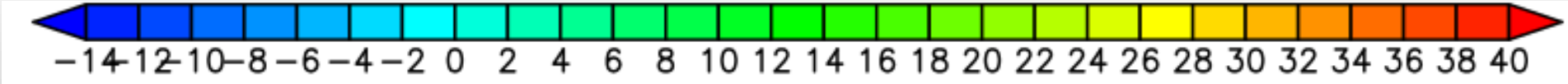






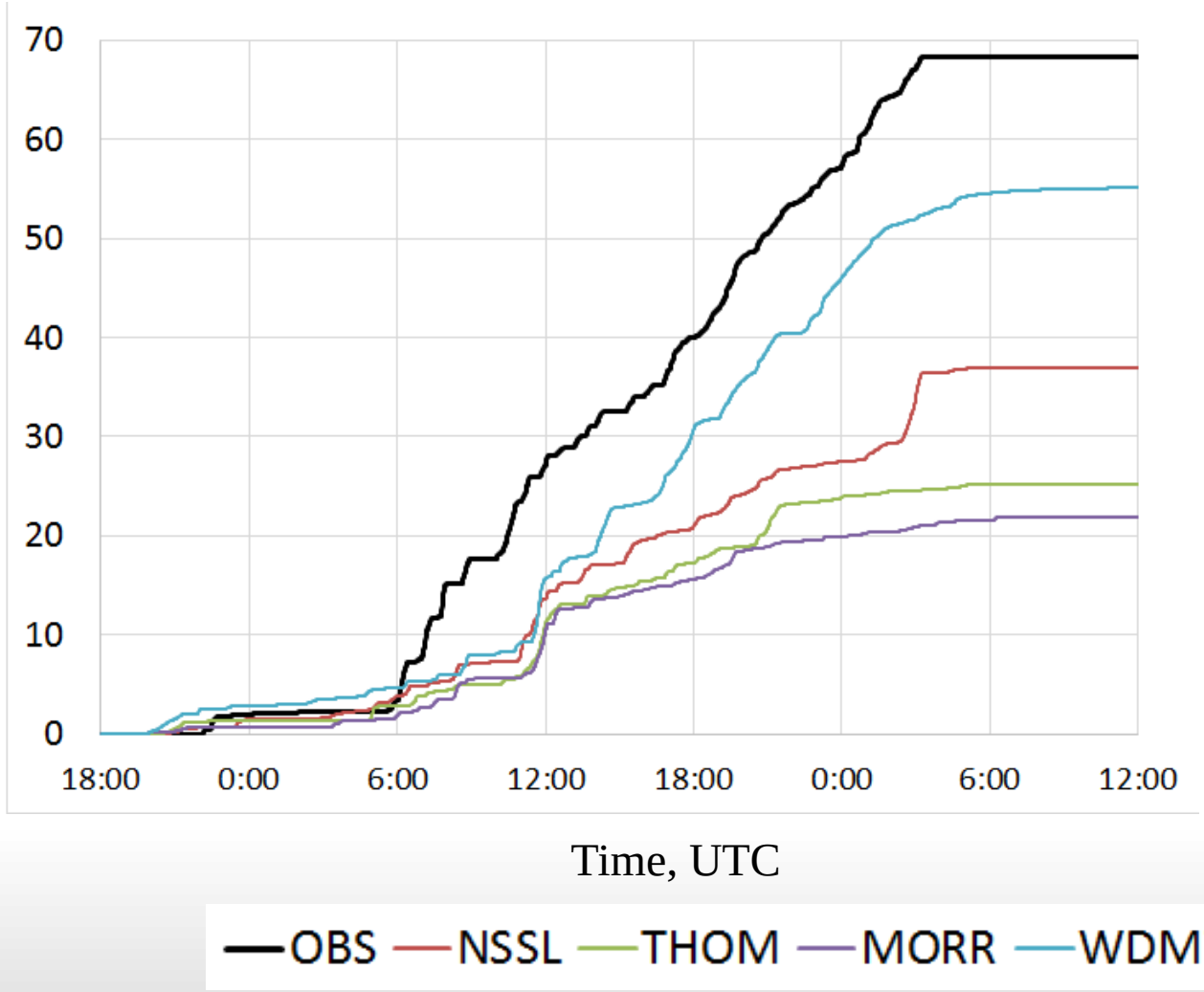




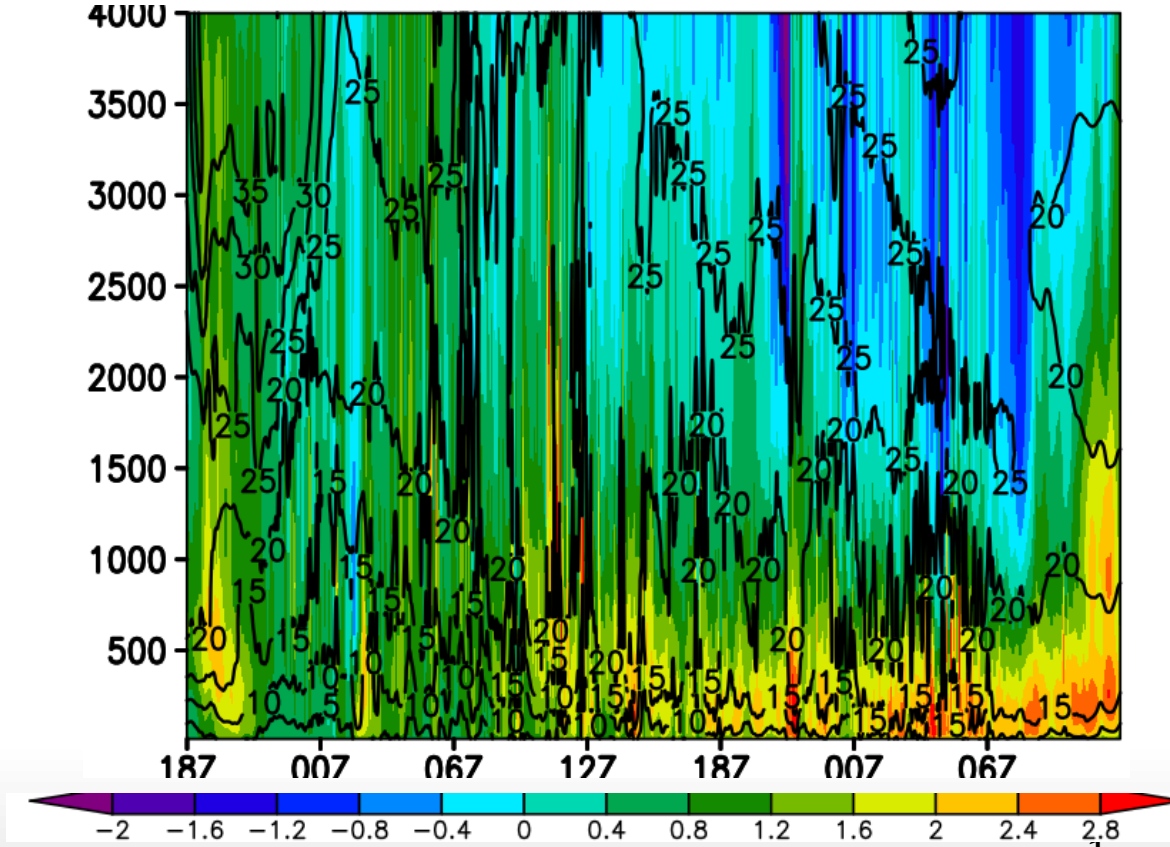


Simulation of precipitation amount, wind and low-level orographic uplift at Cabramurra: 05-07-Aug, 2018

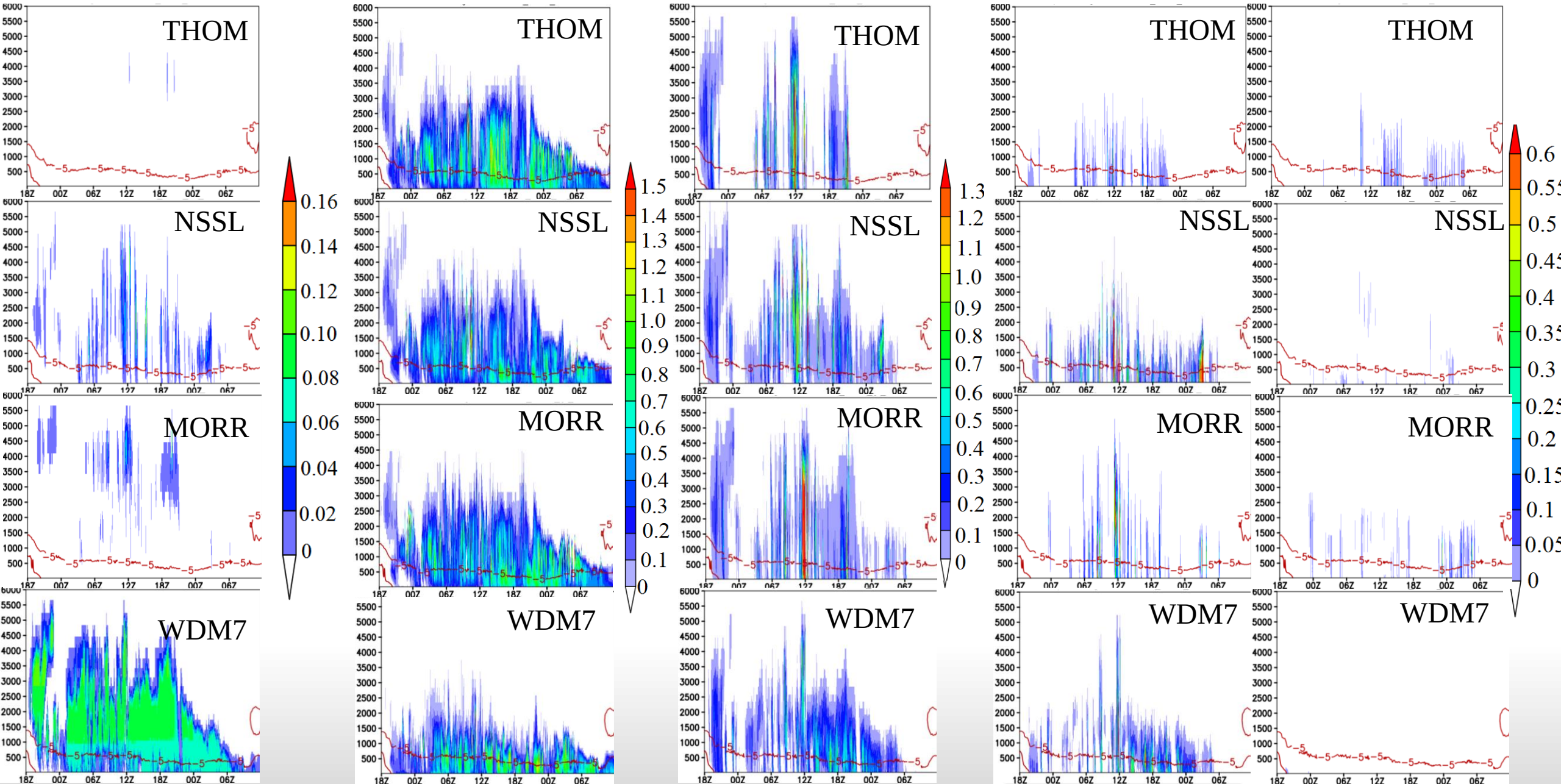
1-min observed and simulated accumulated precipitation (mm)



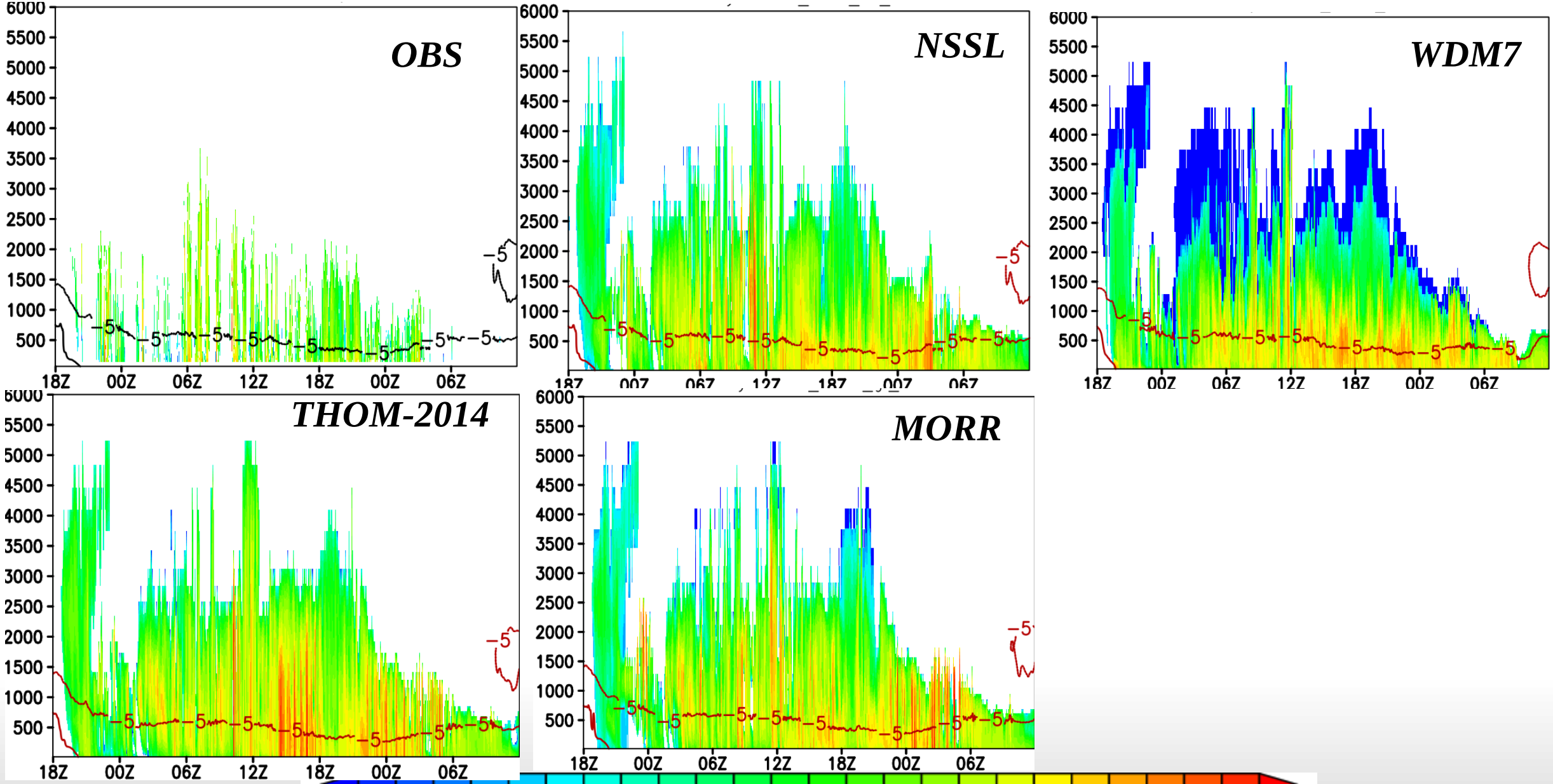
Time-height cross-section of vertical velocity (shaded) and u-wind (cross-barrier) component (contours) at Cabramurra, THOM run



Simulated time-height cross-sections of hydrometeor species (g kg^{-1}) at Cabramurra for 05-07Aug, 2018 case



Simulated and observed equivalent reflectivity at Cabramurra for 05-07-Aug 2018 case: Micro Rain Radar operates at 24 GHz, while the WRF simulations are from Quick beam radar simulator at 35 GHz



Summarizing the results

- Overall, the THOM, NSSL and MORR microphysical schemes are able to produce the observed spatial patterns of precipitation and post-frontal supercooled liquid water (SLW) clouds over the Snowy mountains using 1 km WRF runs.
- The WDM7 scheme shows the lowest performance simulating too intense cloud icing which results in strongly overestimation of precipitation over the high-elevated parts of Snowy Mountains (> 1500 m a.s.l.)
- Simulated time-height cross-sections for the vertical velocities, u-wind component and hydrometeor species at Cabramurra indicate orographic uplift and post-frontal SLW clouds
- However, the airmass was much more unstable for the post-frontal period of the second event (05-07-Aug, 2018) leading to deeper (convective) clouds and intense precipitation

Thank you!