Recent development in Australian near real-time water vapour platform using NPI for weather and climate studies

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Overview

The GNSS signal is refracted and delayed during its propagation in the atmosphere, especially through the troposphere. The delayed signal carries significant information about the state of the troposphere so it can be used to determine precipitable water vapour (PWV) contents in the troposphere. Recently, the advance in GNSS technologies suggests that the footprint of the GNSS signal captured can be very valuable for both climate and weather forecasting, especially nowcasting and severe weather forecasting.

The Australian Natural Disaster Resilience Grant (NDRG) scheme

RMIT University together with its collaborators is developing an Australia near real-time PWV monitoring platform for a project funded through the Australian Natural Disaster Resilience Grant (NDRG) scheme. The aim of the project is to develop an advanced PWV monitoring platform initially covering the state of Victoria using the Australian Positioning Infrastructure (NPI) networks (see Figure 1) together with space-borne GNSS and meteorological atmospheric observing systems for reducing the risks/impact of natural weather disaster events. The current RMIT near real-time system (NRT) is shown in Fig. 2.

- **Partnership**

  RMIT University, Bureau of Meteorology, Department of Environment and Primary Industries (DEPI), Univ. of Melbourne, CRC-SI, Met Office/UK

- **Objectives**

  (1) to develop a smart GPS-based PWV estimation system from GPS-derived tropospheric delay estimates

  (2) to assimilate the above results to the Australian Community Climate and Earth-System Simulator (ACCESS) model.

- **Complementary to the EU COST Action project**

  This study is complementary to the current EU COST Action Program - Advanced GNSS tropospheric products for monitoring severe weather events and climate (GNSS4SWEC) that SPACE/RMIT is involved in leading the Australian efforts.

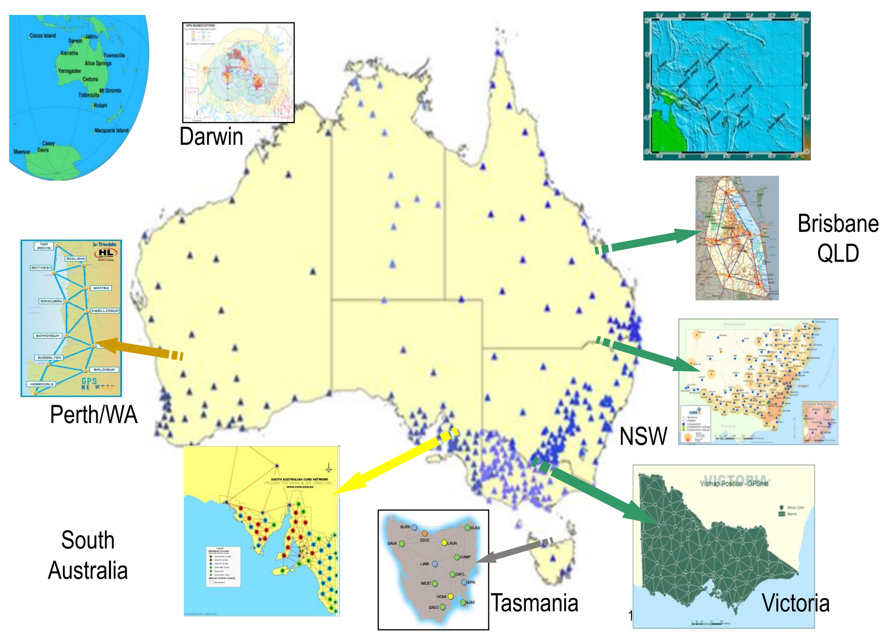


Figure 1. The Australian Positioning Infrastructure (NPI) networks

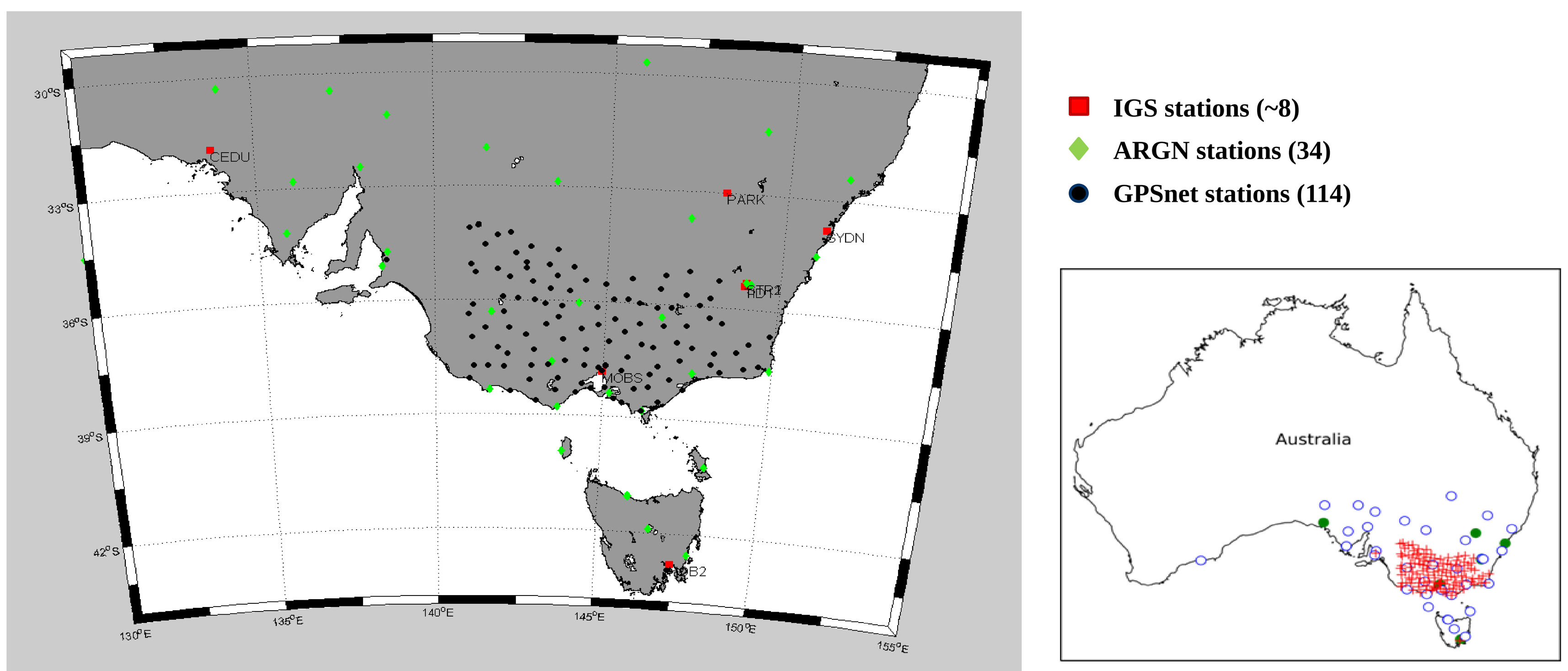


Fig. 2 The RMIT NRT system includes 156 stations with an average distance of around 70 km

Data processing for the RMIT NRT system

The standard data source for GNSS-derived atmospheric values is the zenith tropospheric delay (ZTD). The following three processing scenarios were proposed and tested for ZTD estimation in near real-time.

The first two are double-difference (DD) solutions with fixed/float ambiguity resolutions and the ZTD estimation procedures are shown in the left panel of Fig. 3. The first column includes data preparation and the automated Bernese V5.2 software processing management. Note that the steps in the ambiguity resolution procedure are only for the fixed ambiguity resolution.

The last scenario is the precise point positioning (PPP) using the iono-free linear combination from a single station, see Fig. 3 (right panel) for its processing flowchart.

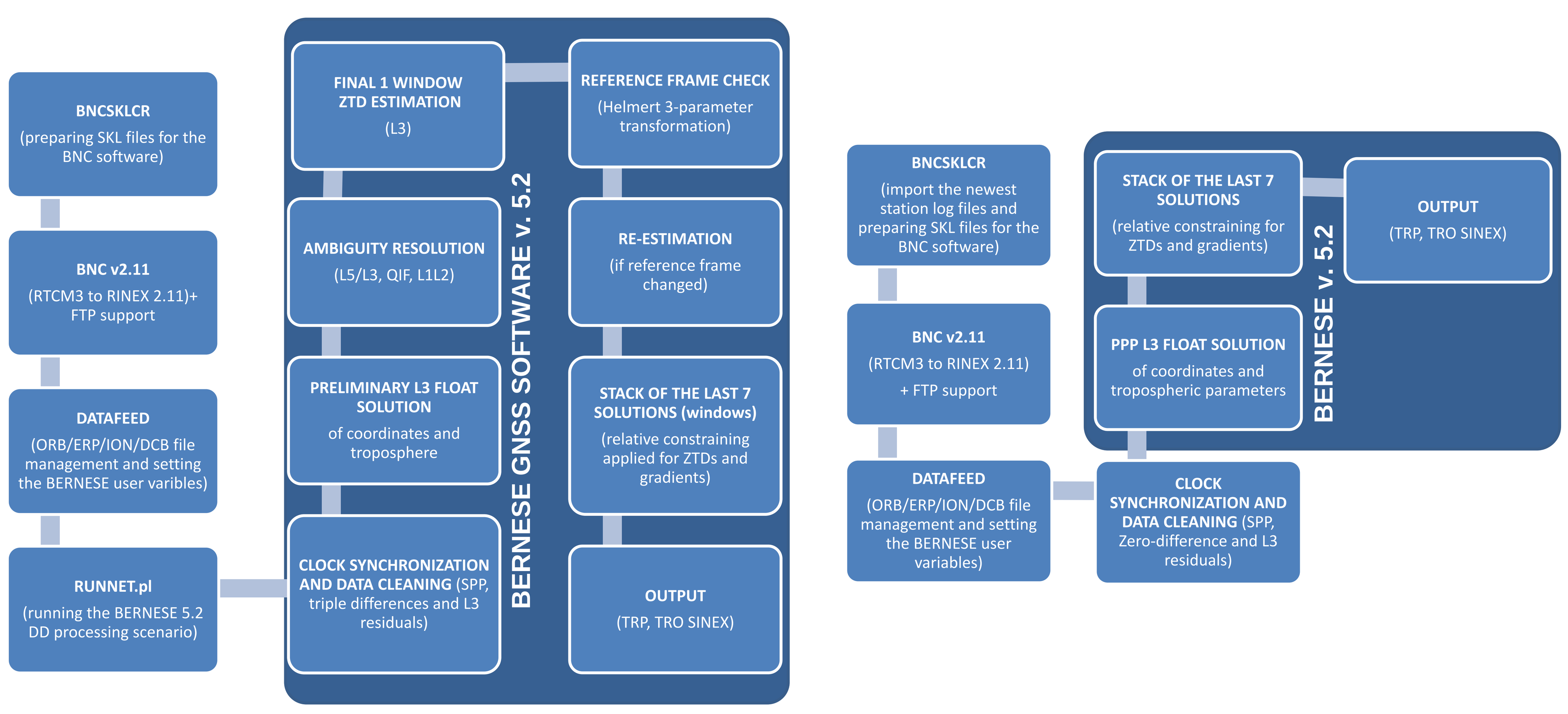


Fig. 3 Data processing flowcharts for the DD (left) and PPP (right) solutions

Results and Assessment

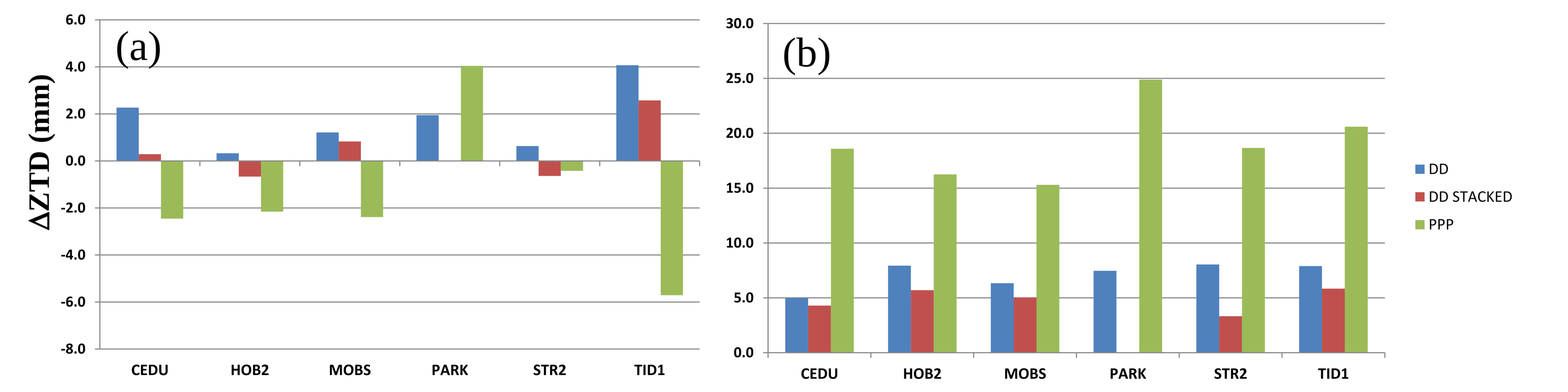
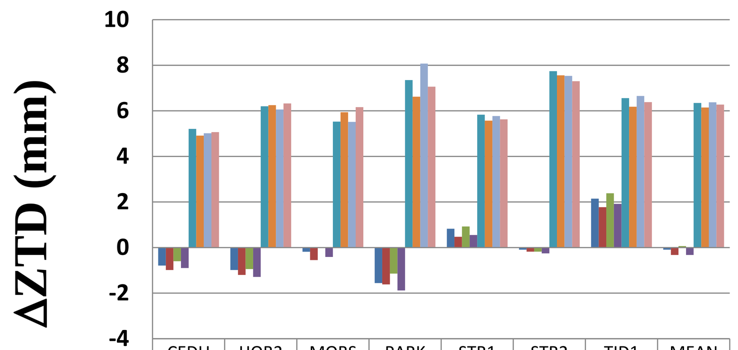


Fig. 4 Comparison with CODE Rapid ZTD of 6 stations: (a) ZTD bias and (b) ZTD standard deviation



	CEDU	HOB2	MOBS	PARK	STR1	STR2	TID1	MEAN
bias FLOAT STACKED	-0.79	-0.99	-0.18	-1.56	0.82	-0.09	2.15	-0.09
bias FLOAT SINGLE	-0.99	-1.20	-0.55	-1.62	0.47	-0.18	1.77	-0.33
bias FIXED STACKED	-0.60	-0.94	0.01	-1.15	0.93	-0.18	2.38	0.06
bias FIXED SINGLE	-0.90	-1.29	-0.41	-1.88	0.55	-0.25	1.92	-0.32
std. dev. FLOAT STACKED	5.21	6.20	5.53	7.35	5.83	7.74	6.56	6.35
std. dev. FLOAT SINGLE	4.91	6.25	5.94	6.62	5.57	7.56	6.18	6.15
std. dev. FIXED STACKED	5.02	6.06	5.52	8.07	5.77	7.54	6.65	6.37
std. dev. FIXED SINGLE	5.06	6.32	6.16	7.06	5.63	7.30	6.38	6.27

Fig. 5 Comparison with FINAL IGS ZTD for the period DoY 091–168 (2015, ~2.5 months)

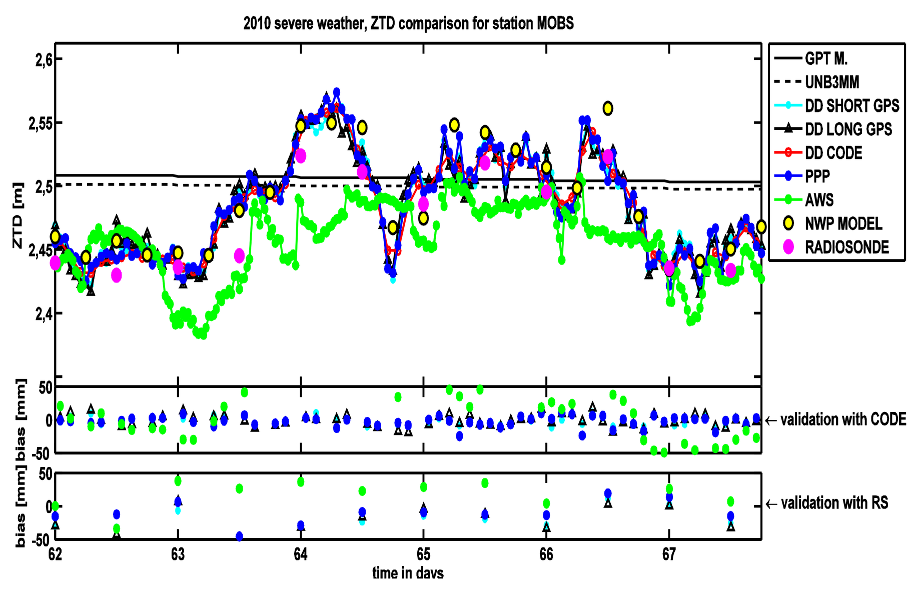
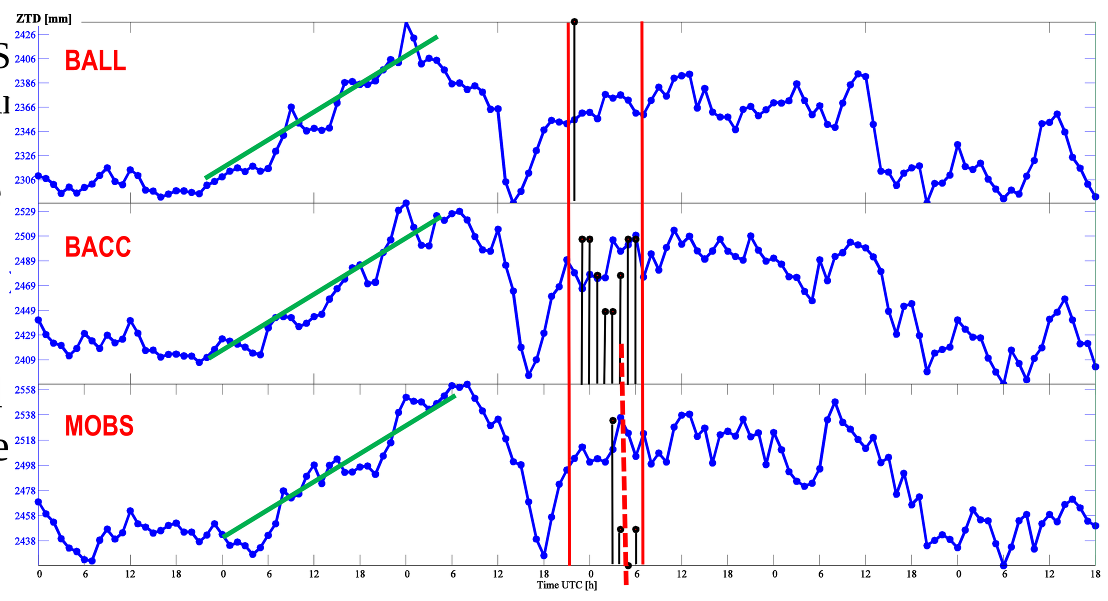


Fig. 6 Validation using radiosonde at the MOBS station as the reference of ZTD

NPI for weather and climate study

Fig. 7 ZTDs derived from three CORS stations over the storm occurred at 4 am (UTC, 2 pm local time) on March 6, 2010 in Melbourne for storm passage detection (Zhang et al, 2015)

The passage is well detected and ~8hrs between the passage of the cold front and dissipation is observed.



05/March 06/March

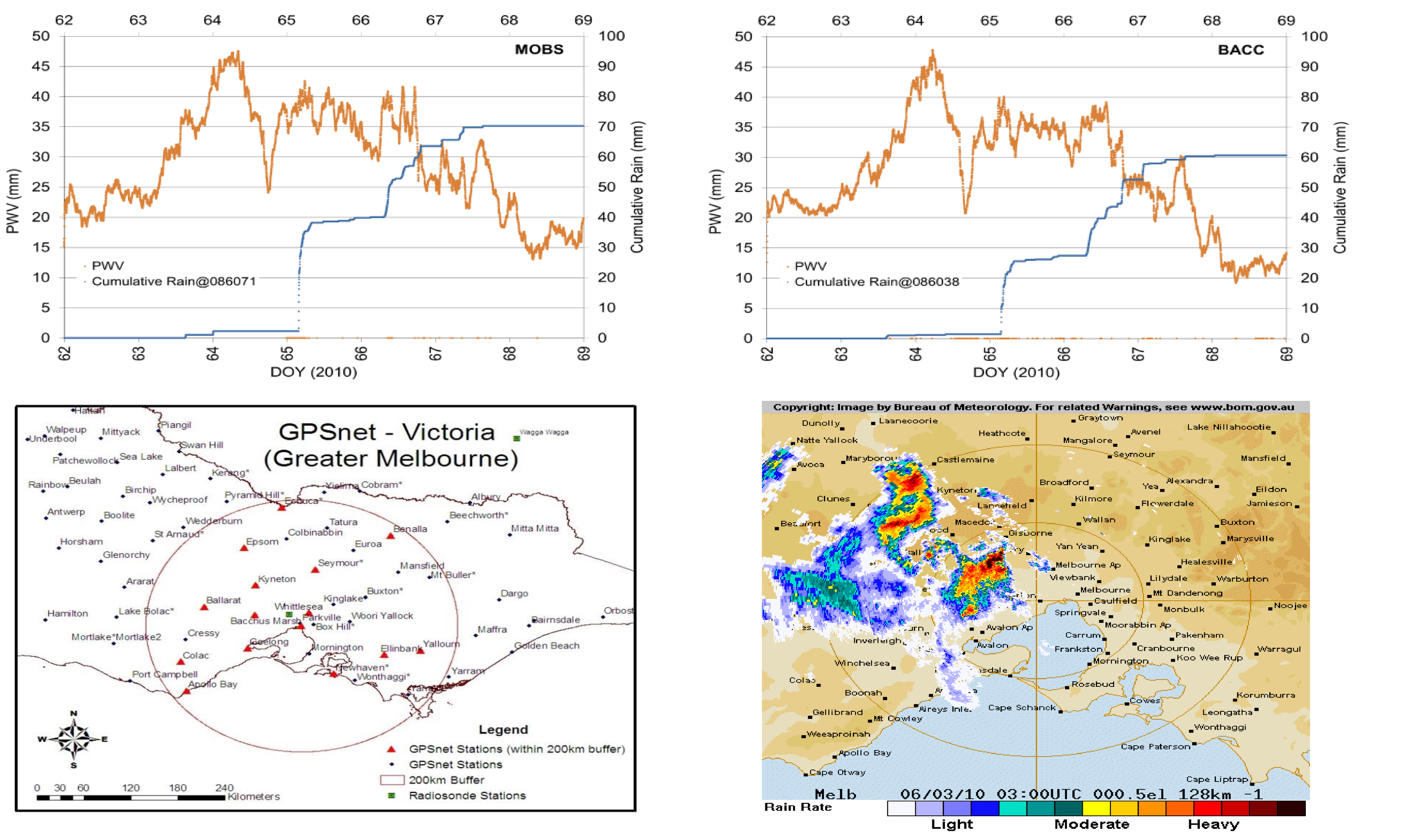


Fig. 8 Correlation between PWV and rainfall (Choy et al, ASR)

Summary and conclusive statements

This contribution presents recent Australian effort and significant achievements in GNSS atmospheric sounding. The advanced NRT platform developed using the Australian NPI through the NDRG project awarded for both severe weather and climate study is introduced. The major outcomes include

- Signatures of severe weather has been investigated following our success in operational use of GPS radio occultation in the Australian weather forecasting models (ACCESS model) in 2012
- Good results achieved through the advanced RMIT NRT ZTD platform :
  - Operationally, ~150 GPS CORS stations
  - Much better than the initial requirements of the EGVAP definition (0.06 mm, 6.3 mm)
  - The expected IWV accuracy is better than 1 kg/m2
- It is concluded that GNSS as a robust environmental sensing technology
  - can provide continuous and accurate measurements of the atmosphere with good spatial and temporal resolutions – very important for meteorology
  - Has a good potential for forecasting severe weather events and now-casting
  - Is of great importance to data void regions, particularly many large areas in Australia with less dense meteorological sensors deployed and the Antarctic and large ocean areas, in the middle of "nowhere".

Acknowledgements

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- Part of this research has been published in journals including Wang et al (JGR, 2015, 2016), Zhang et al (IEEE/JSTAR, 2015), Yuan et al (JGR, 2014),) Rohm et al (Atmospheric Research, 2014), Rohm et al (AMT, 2014), Choy et al (ASR, 2013)