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DEPARTMENT OF PHYSICS



On the use of ERA5 Reanalysis data for Precipitable Water Vapor Estimation using Philippine GNSS CORS stations

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Precipitable Water Vapor (PWV)

- Considered as **water vapor that can condense to rain or snow**
- Good **rainfall indicator**
- Precursor to Climatological Studies

$$PWV = \frac{1}{\rho_w} \int_{z_s}^{z_t} \rho q dz$$

where:

ρ_w = density of liquid water

ρ = density of air

q = specific humidity

z_s = surface height

z_t = tropospheric height



How to retrieve PWV?

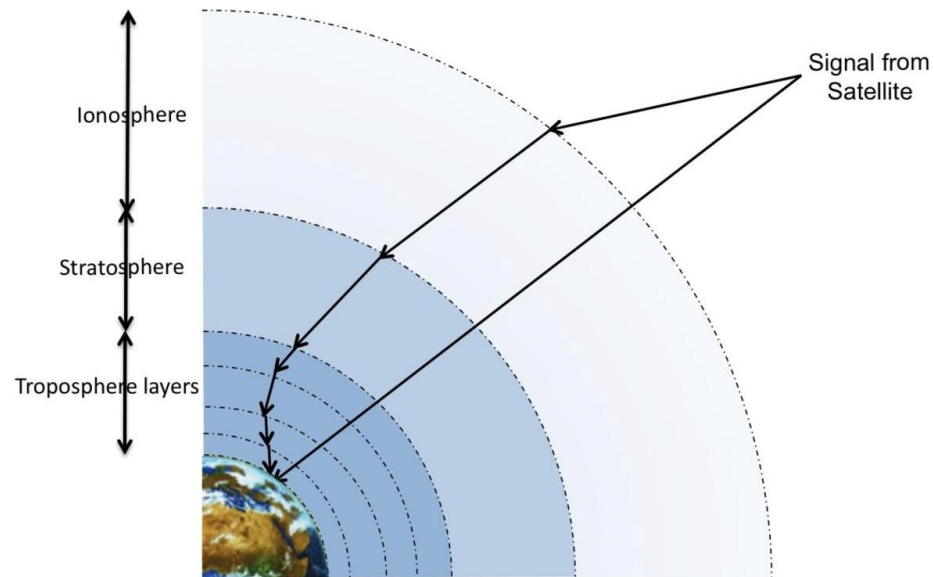
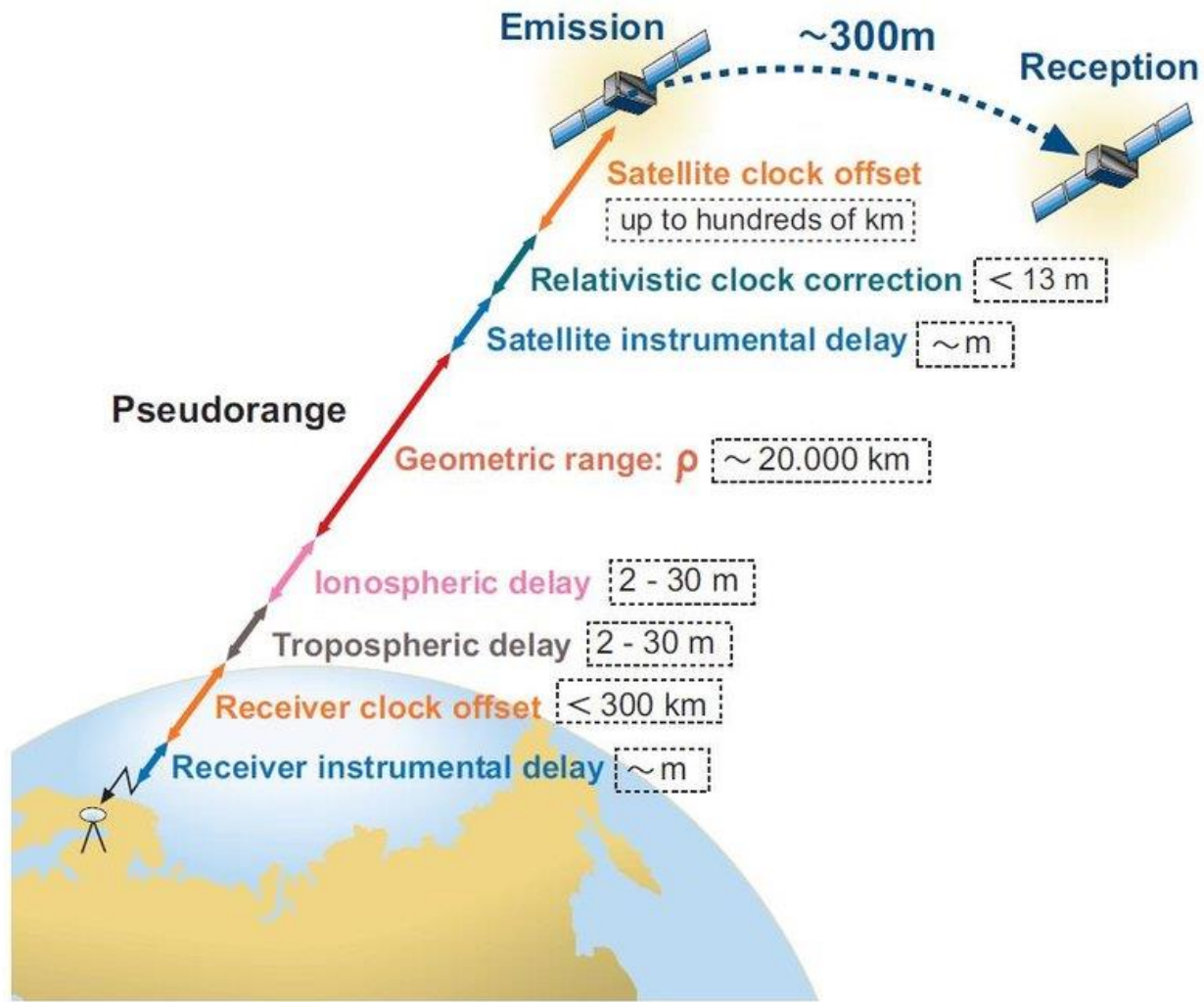
- Radiosonde
- GNSS Estimations
- Microwave Radiometry
- Near Infrared Radiometry
- Radio Occultation
- LIDAR



How to retrieve PWV?

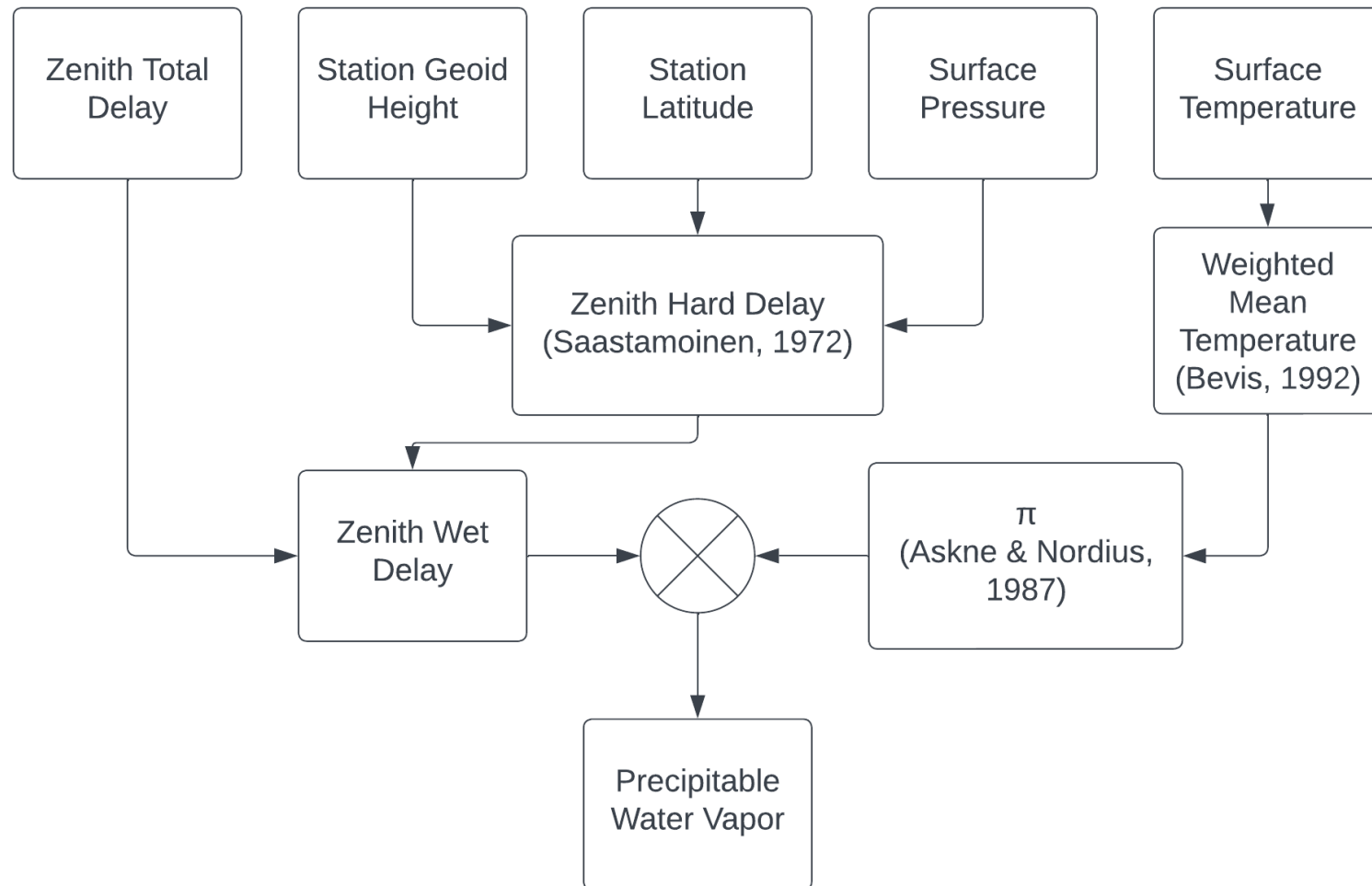
- **Radiosonde**
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GNSS-PWV Estimation

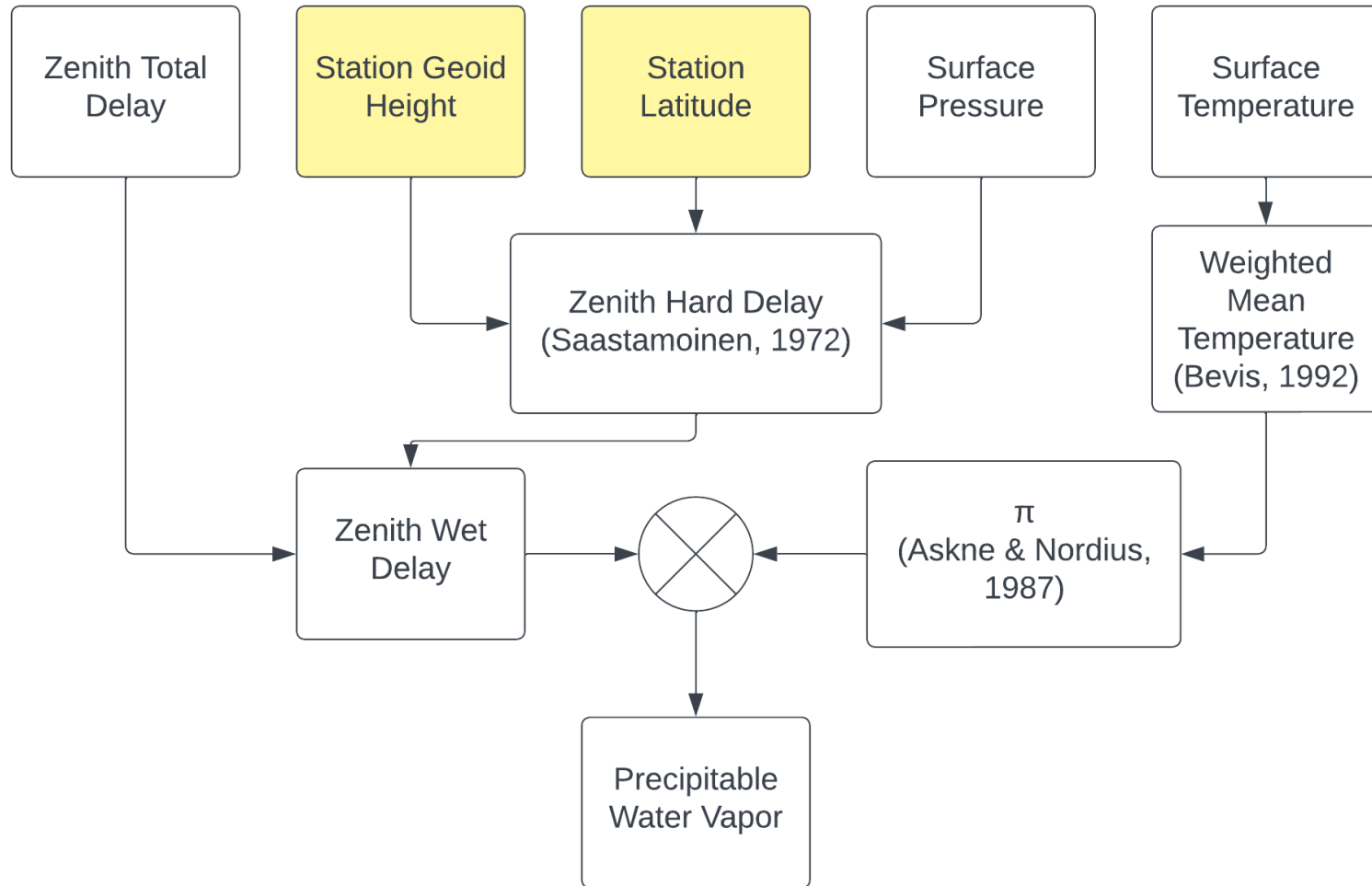


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<https://www.researchgate.net/profile/Samu-Suurinkeroinen/publication/342366057/figure/fig3/AS:905376639754245@1592870020625/GNSS-signal-delay-sources-44-p-96.jpg>

GNSS-PWV Estimation

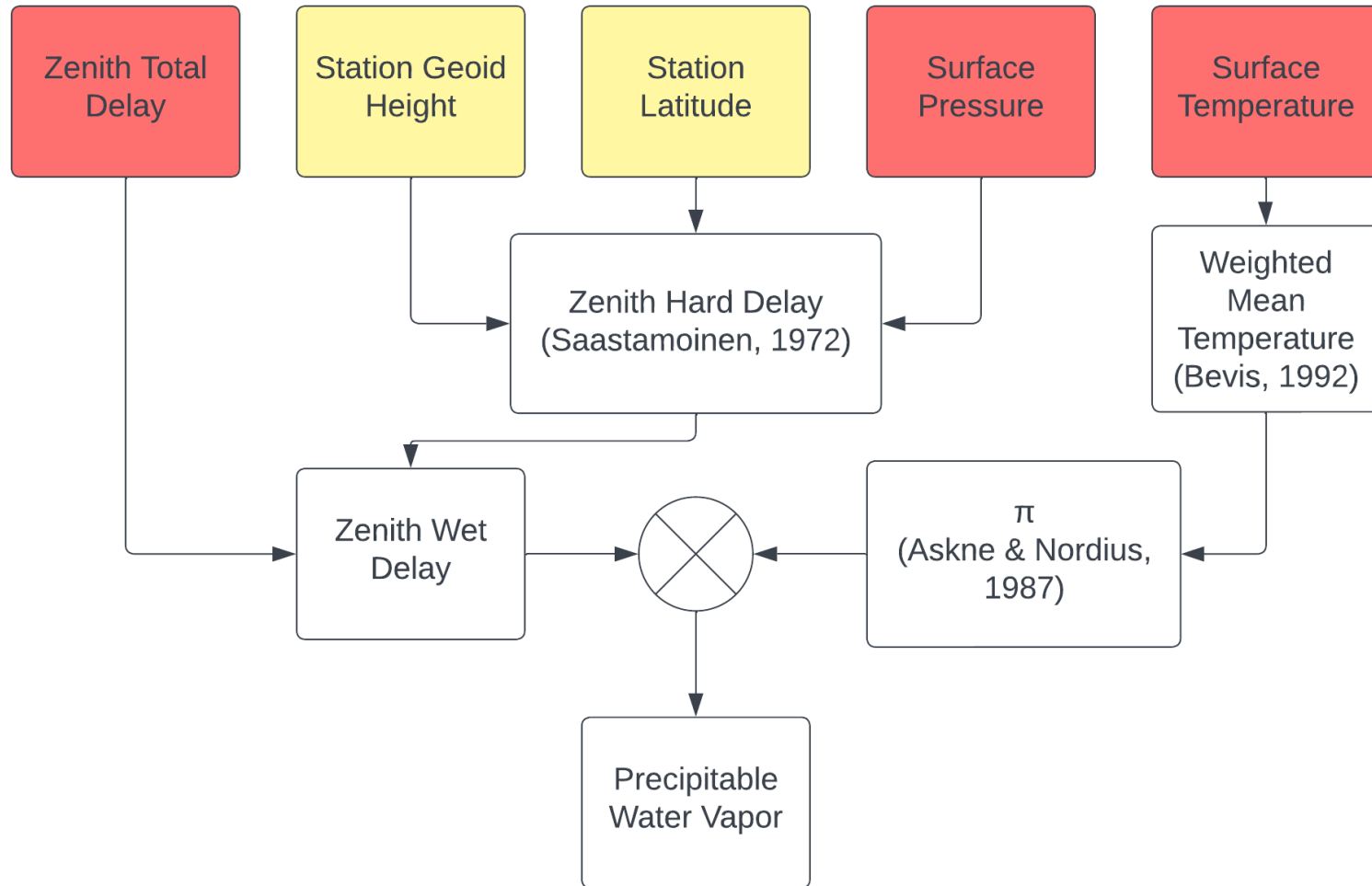


GNSS-PWV Estimation



Station
Dependent
Constants

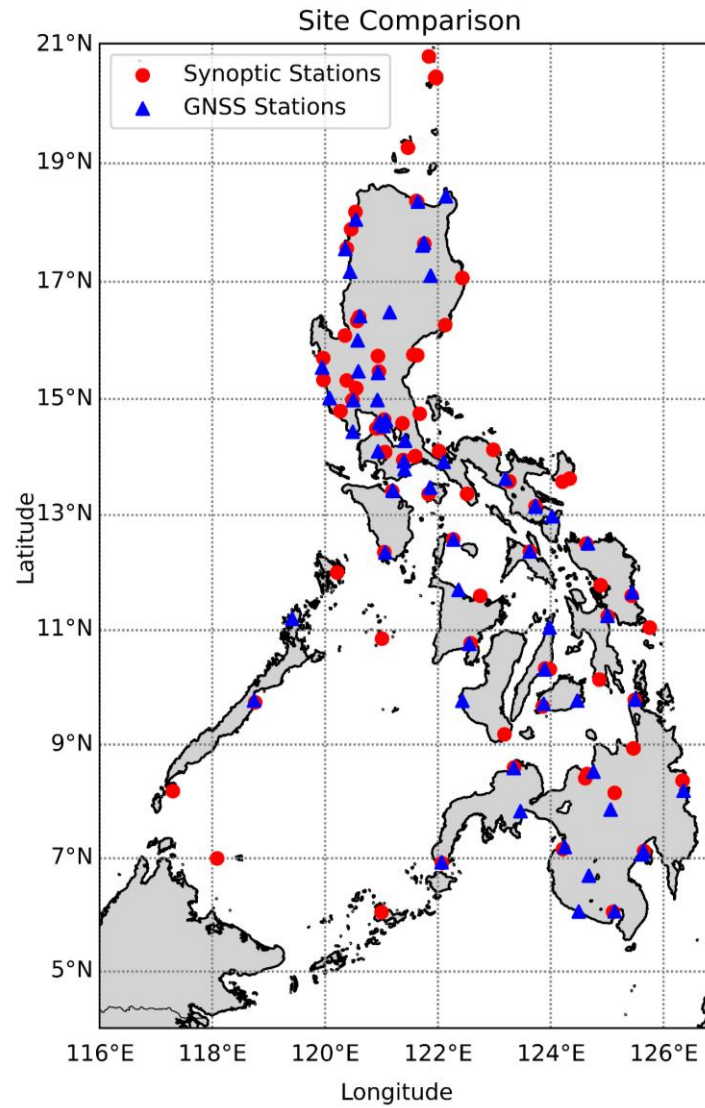
GNSS-PWV Estimation



Station
Dependent
Constants

Observables

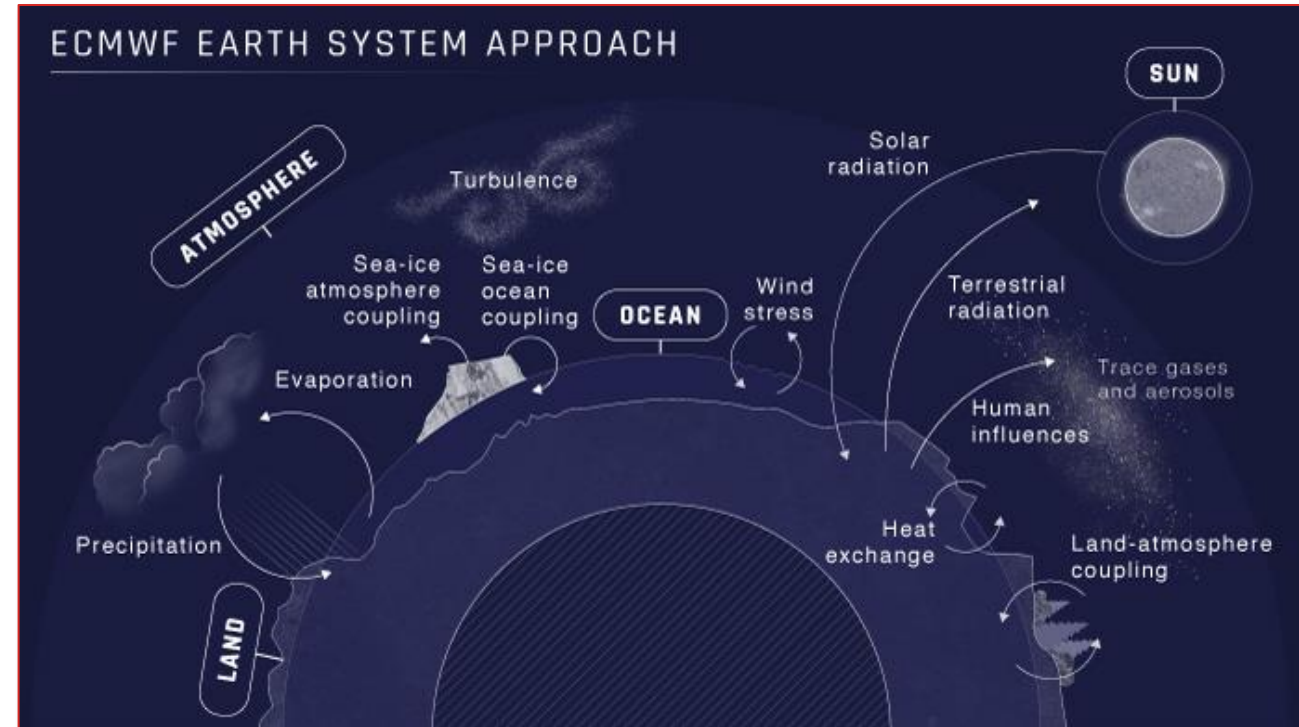
GNSS-PWV Limitations



ERA5 Reanalysis



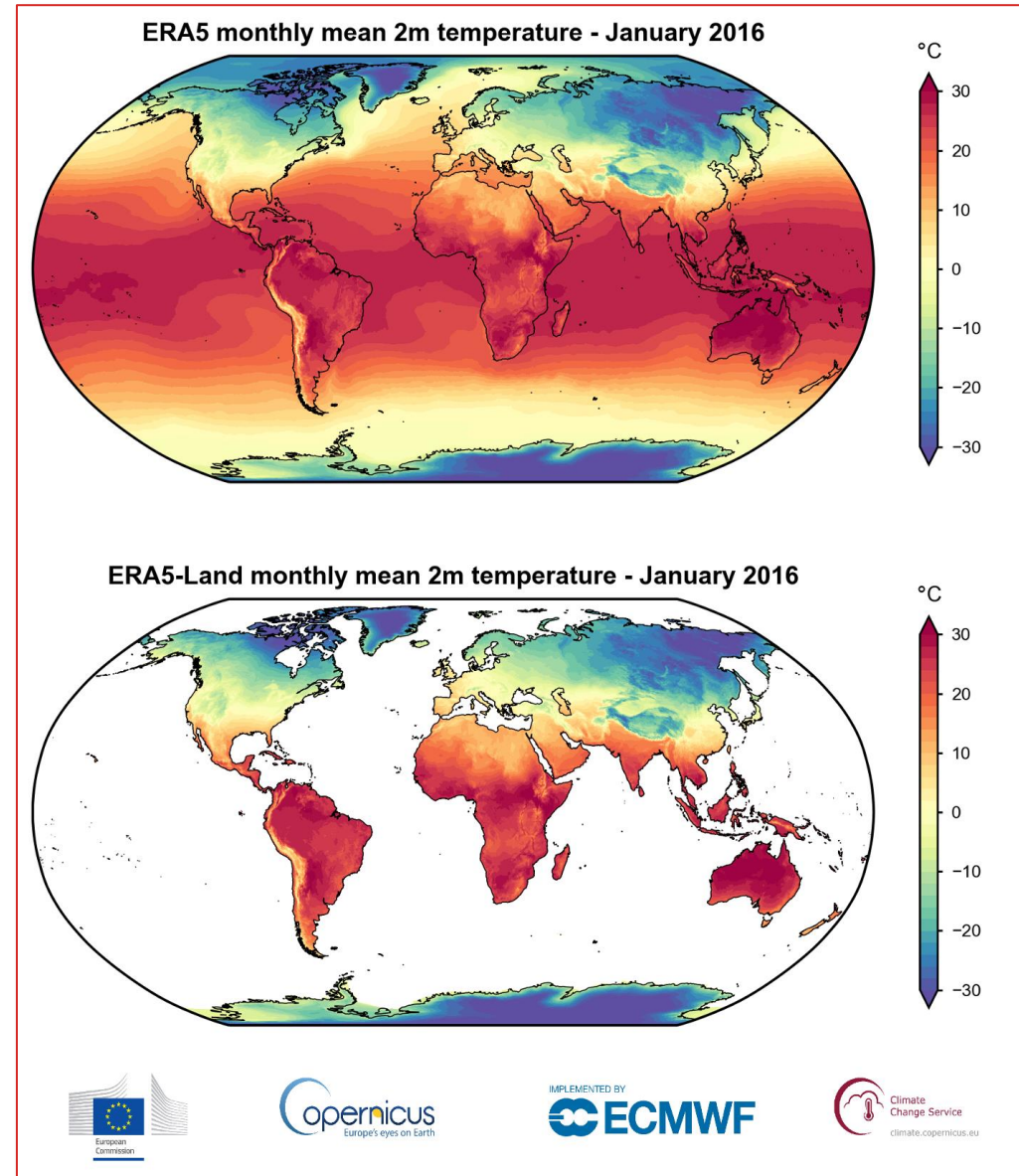
- <https://www.ecmwf.int/en/about/media-centre/focus/2020/fact-sheet-earth-system-data-assimilation>



- <https://www.ecmwf.int/en/about/media-centre/focus/2021/fact-sheet-earth-system-modelling-ecmwf>

ERA5 Reanalysis

- Physics-based model
- High spatial resolution (0.25°x0.25°)
- High temporal resolution (1-hourly)
- All-weather solution



- https://climate.copernicus.eu/sites/default/files/inline-images/era5_t2m_201601.png



Objectives

Main Objective:

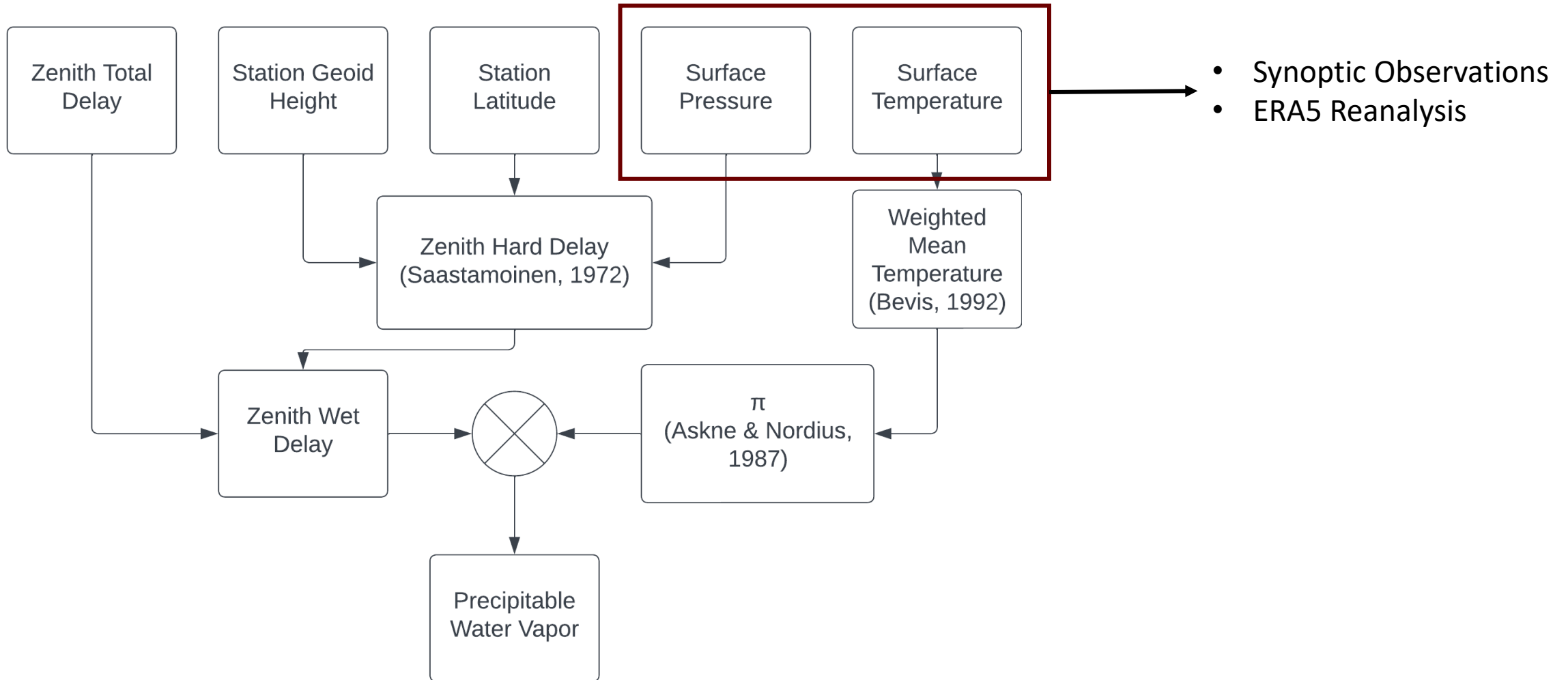
To determine the potential of using ERA5 Reanalysis data alongside GNSS data to compute for PWV in different locations in the Philippines.

Specifically:

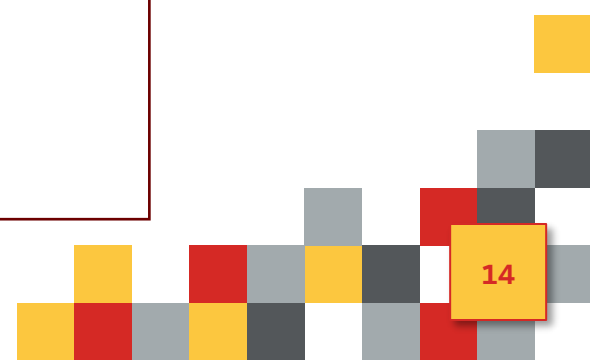
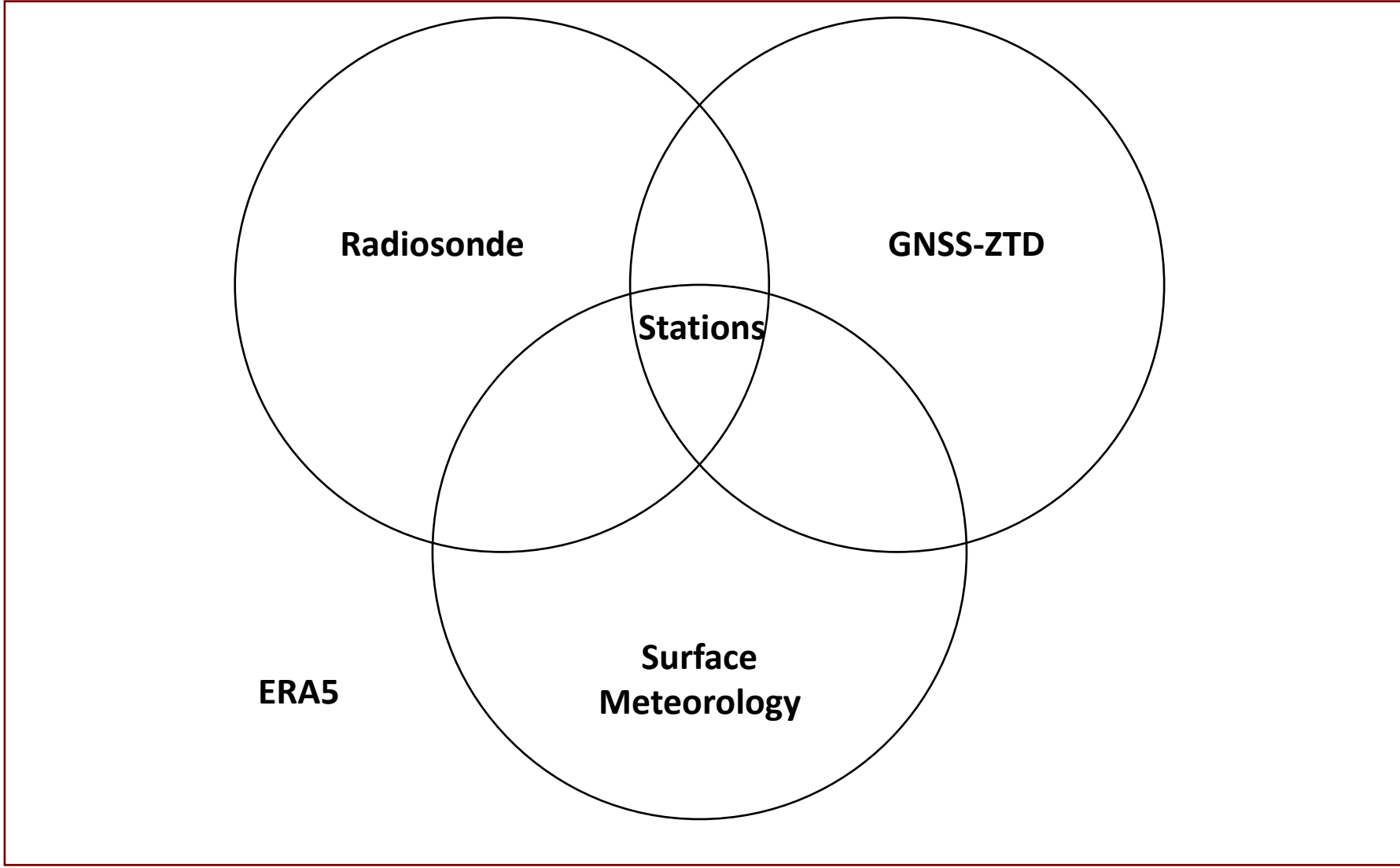
- Determine the **accuracy** of **GNSS-PWV** and compare it against **RS-PWV**;
- Determine the **accuracy** of **GNSS-ERA5-PWV** and compare it against **RS-PWV**;
- Apply **corrections** to **GNSS-ERA5-PWV** and compare it against **RS-PWV**.



Methodology



Data Availability



Sources

Location	RS Station	GNSS Station	Latitude (°)	Longitude (°)	Height _{RS} (m)	Height _{GNSS} (m)
Legazpi, Albay	98444	PLEG	13.161	123.730	16.0	210.125
Mactan, Cebu	98646	PCEB	10.318	123.890	23.0	126.958
Davao City, Davao del Sur	98753	PDAV	7.126	125.643	17.0	98.852

Coverage:

2015 to 2017

12-Hourly PWV

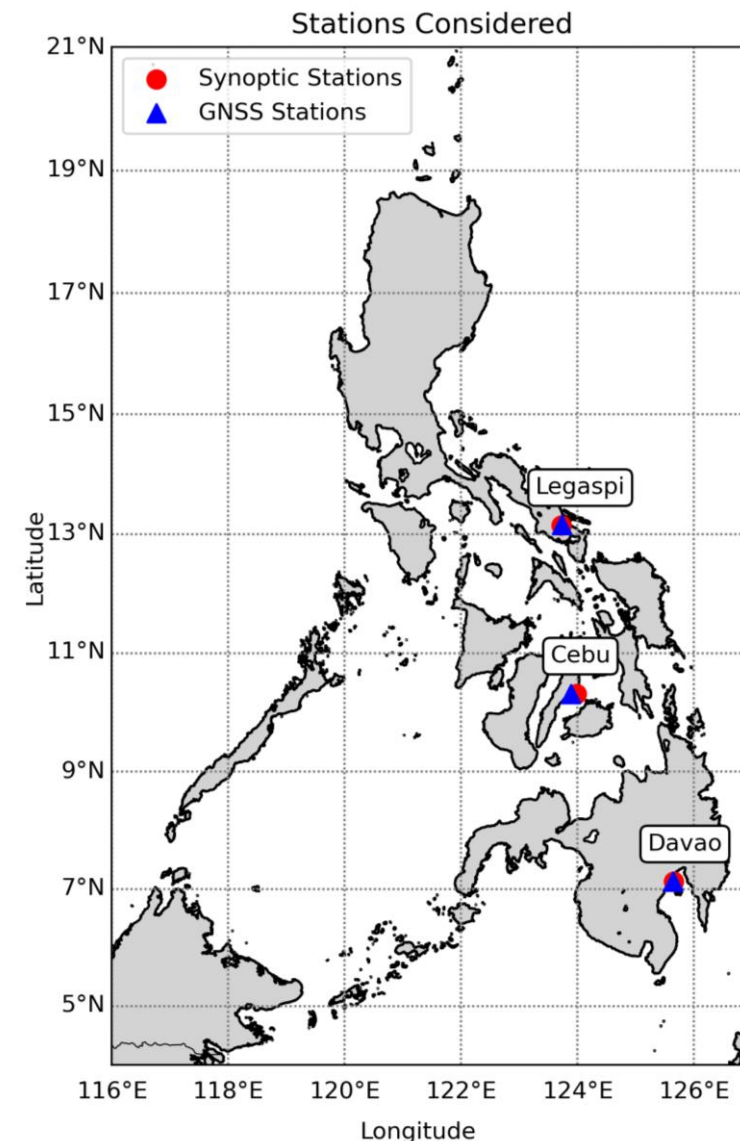
Sources:

Radiosonde – University of Wyoming

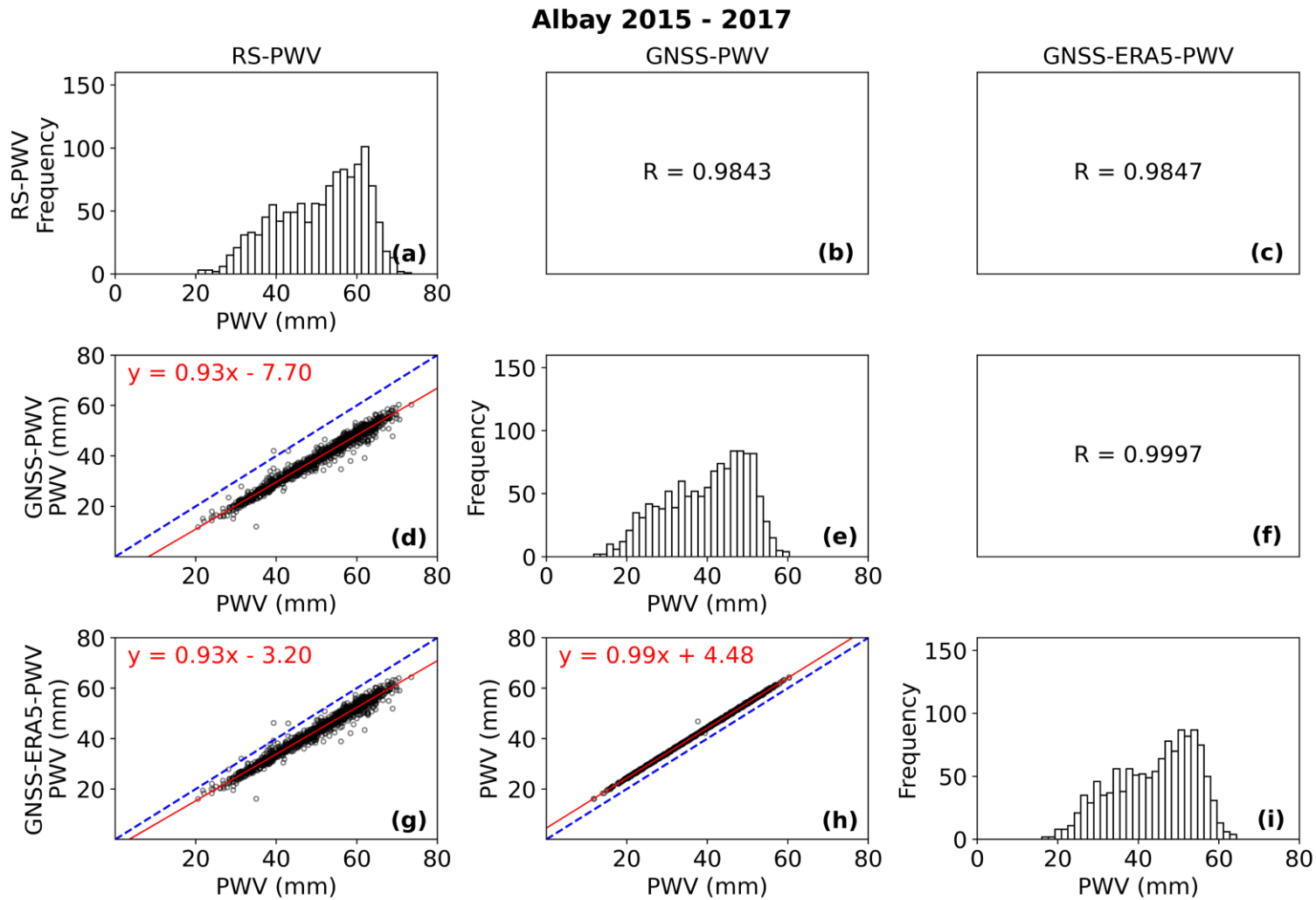
GNSS ZTD – Philippine Active Geodetic Network (PAGeNet)

Surface Meteorology – Ogimet

ERA5 Model – ECWMF

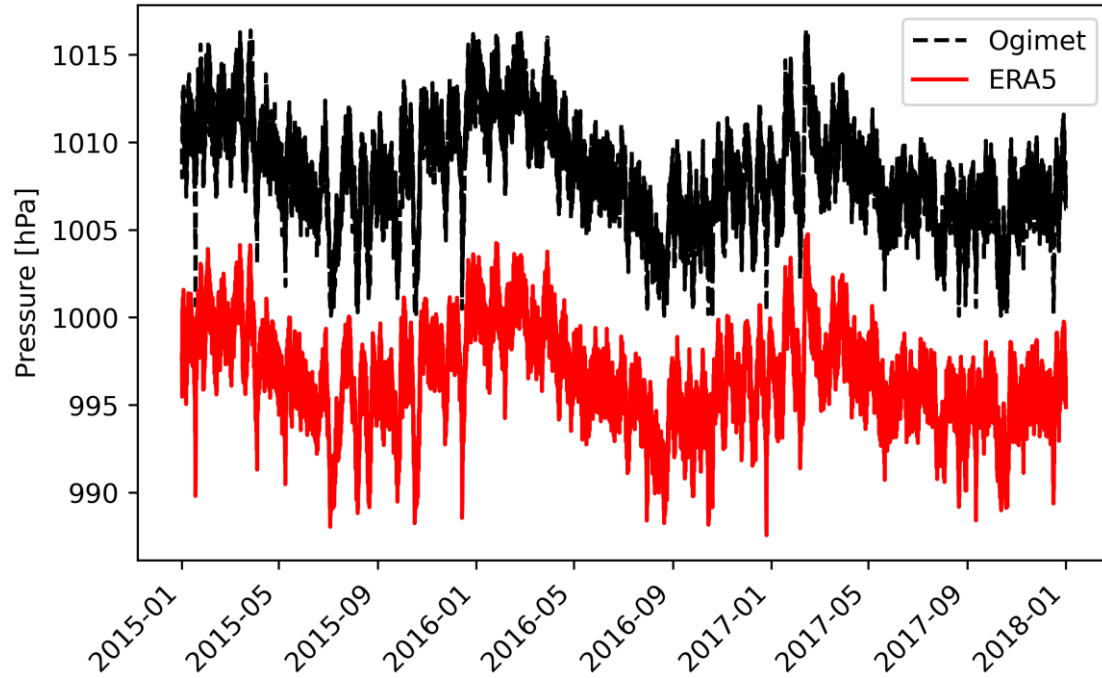


Results - Legaspi

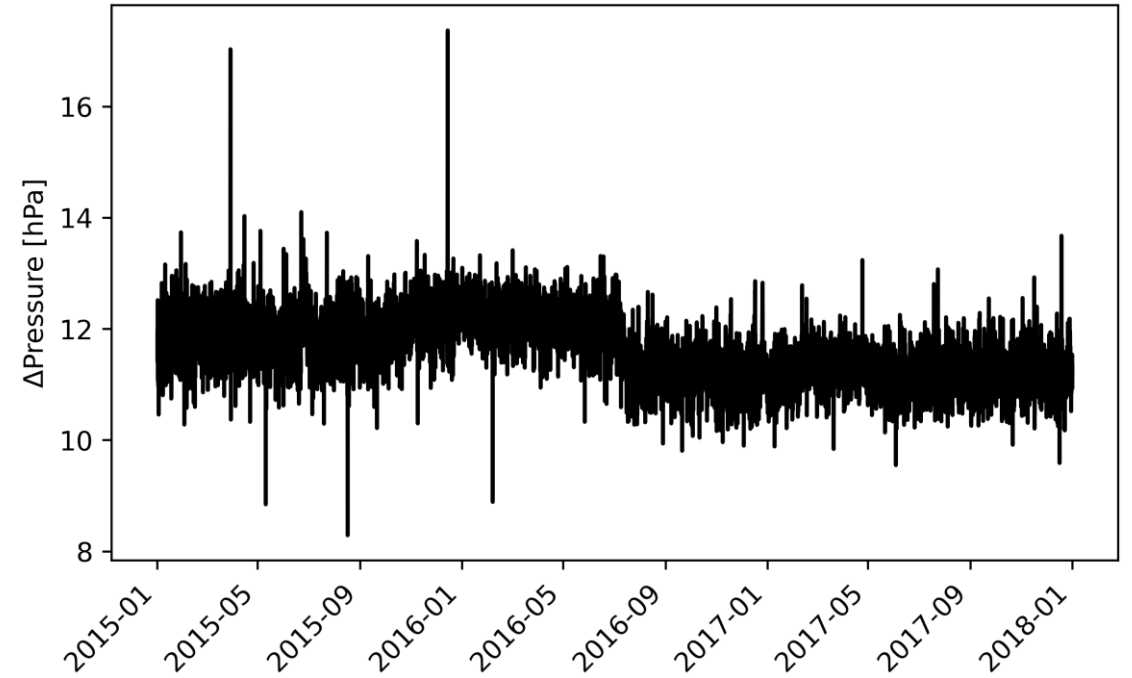


Results - Legaspi

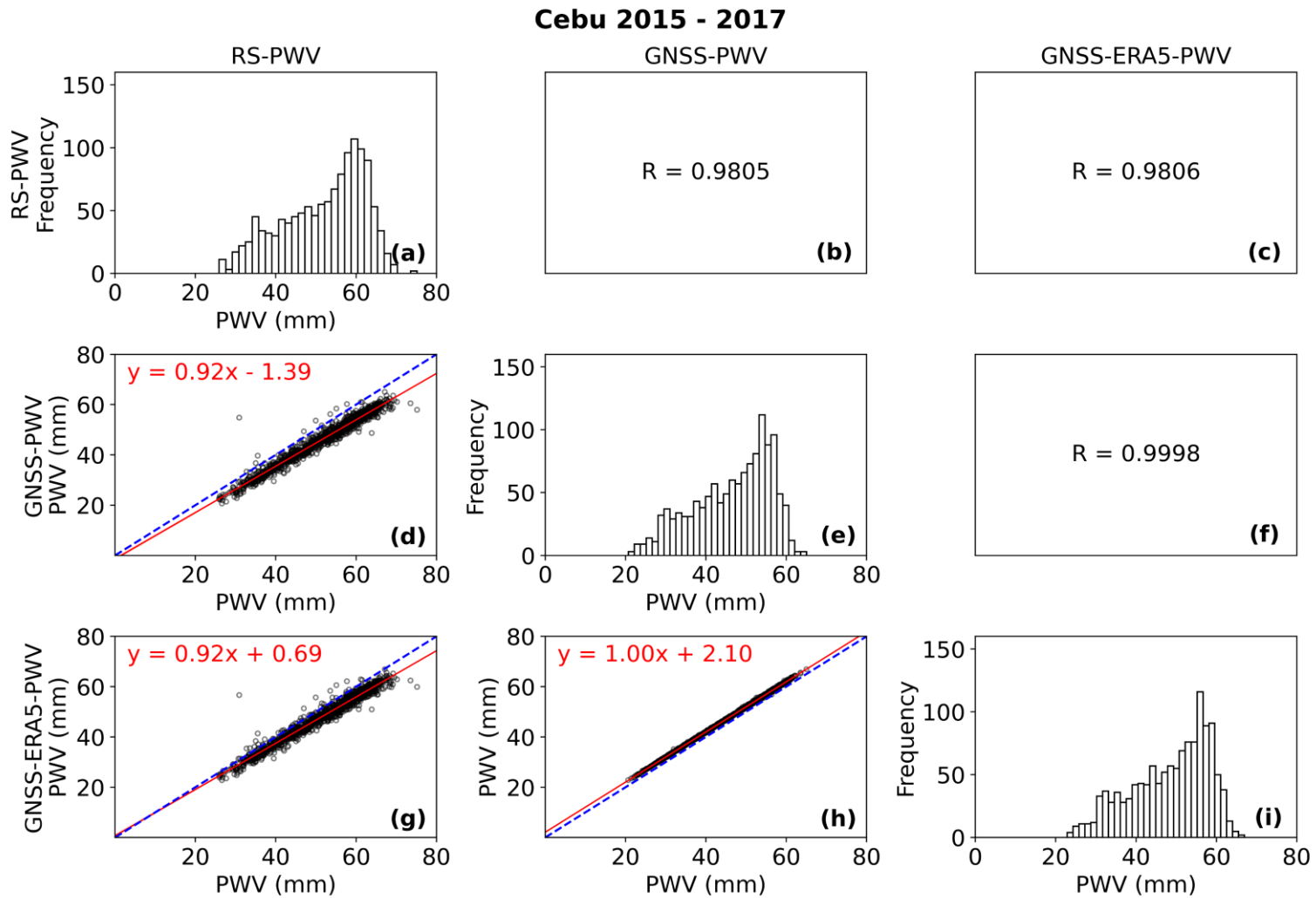
Albay Surface Pressure



Albay Pressure Difference

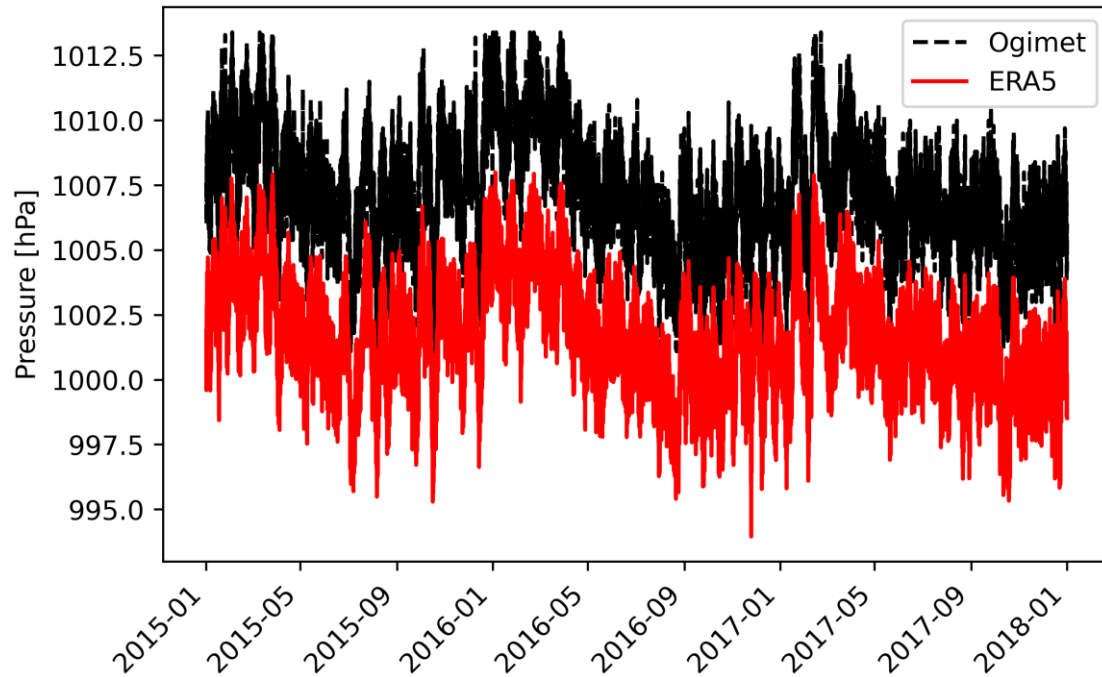


Results - Mactan

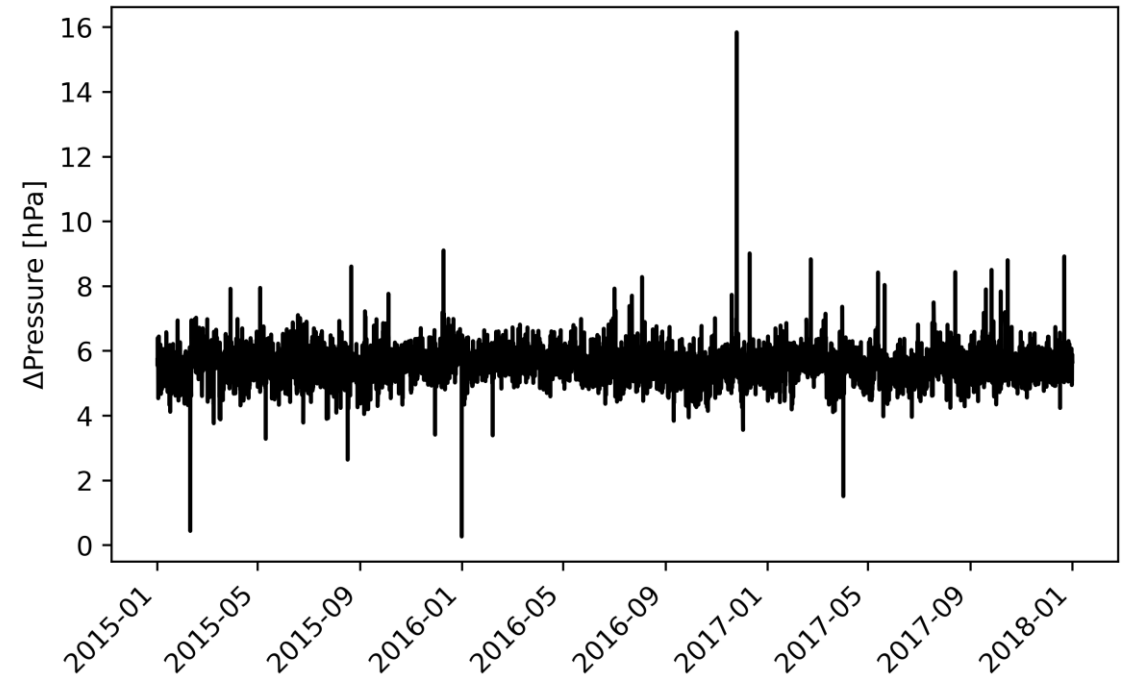


Results - Mactan

Cebu Surface Pressure

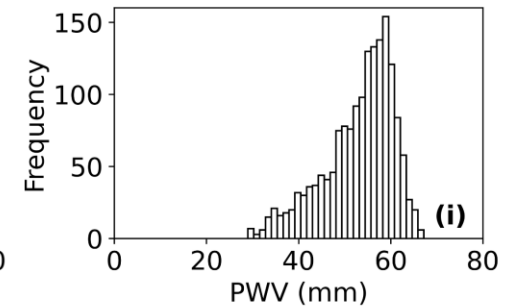
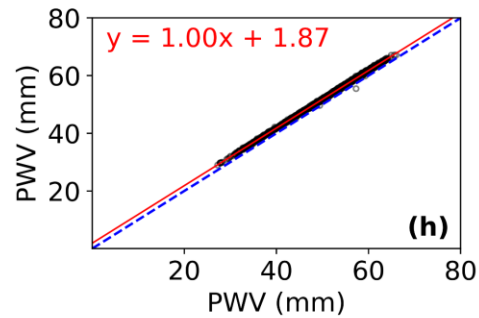
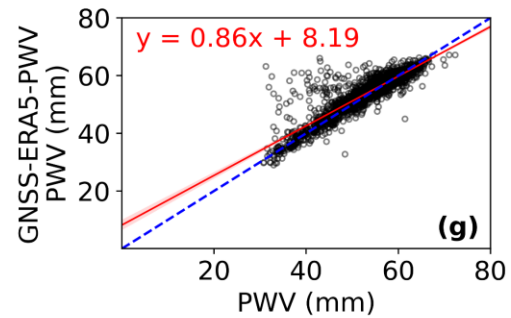
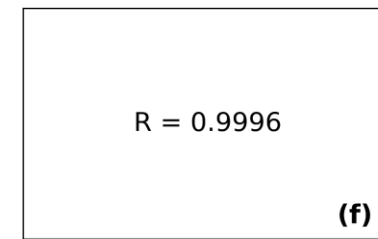
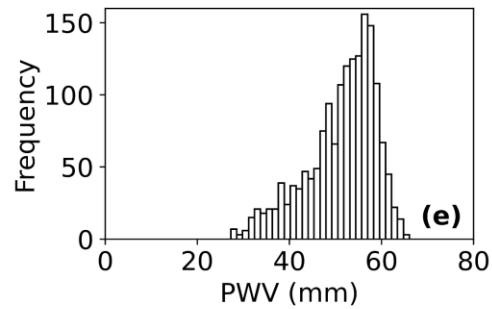
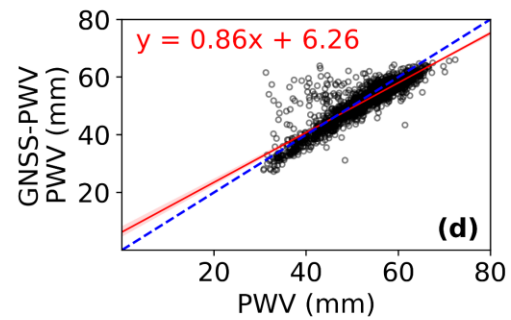
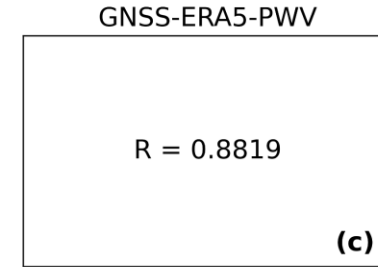
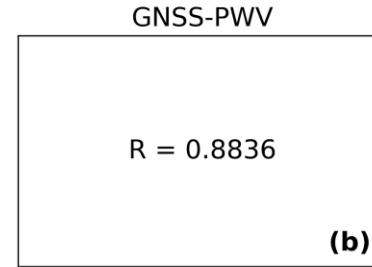
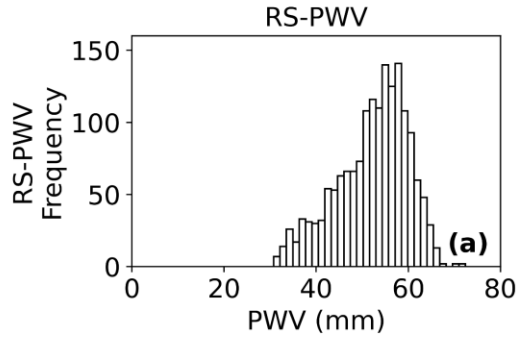


Cebu Pressure Difference



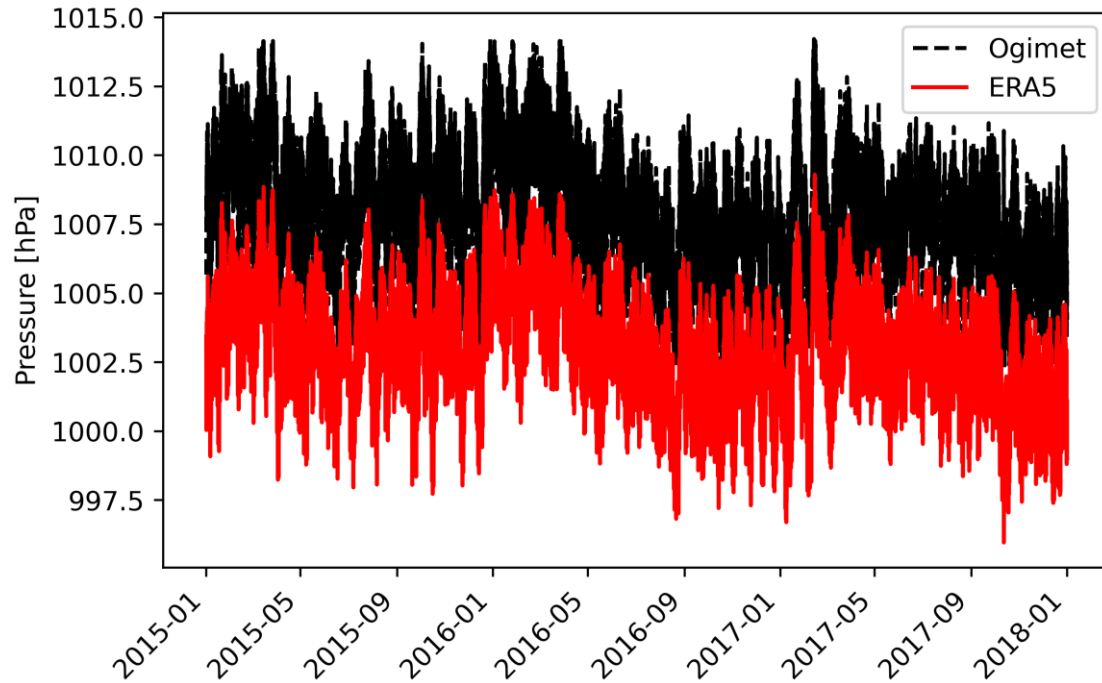
Results - Davao

Davao 2015 - 2017

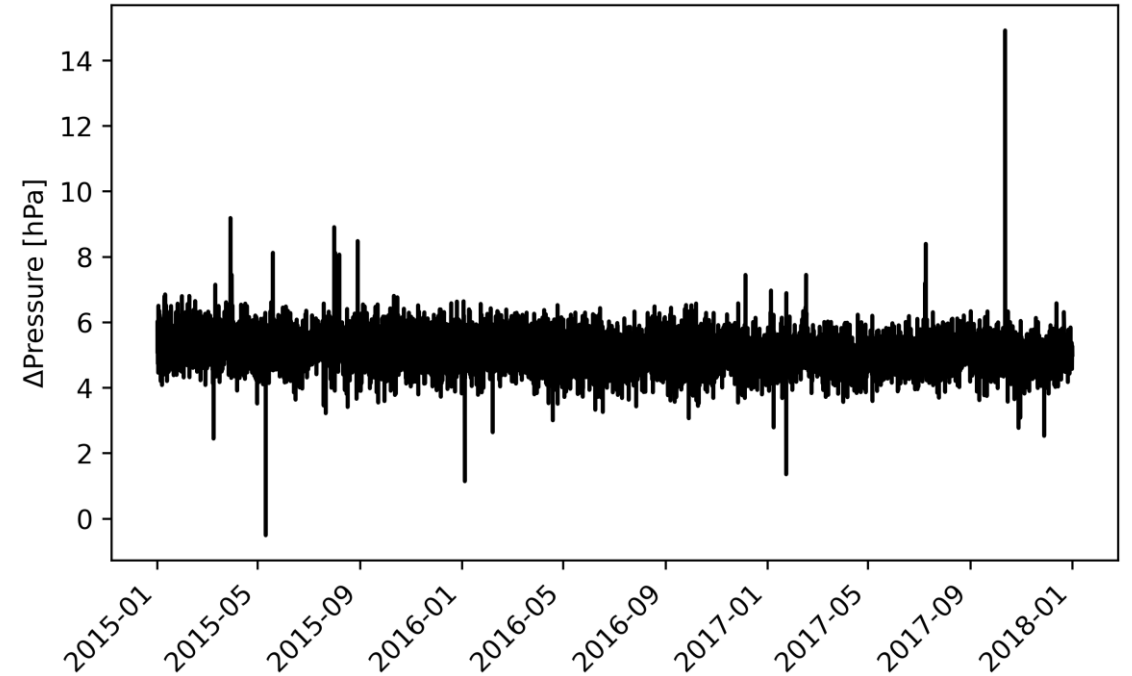


Results - Davao

Davao Surface Pressure



Davao Pressure Difference





Future Work

- Error Analysis
 - Bias
 - Correction
- Application
 - GNSS Stations without Synoptic Data



References

- [1] J. Askne and H. Nordius, “Estimation of tropospheric delay for microwaves from surface weather data,” *Radio Science*, vol. 22, no. 3, pp. 379–386, 1987.
- [2] J. Saastamoinen, “Atmospheric Correction for the Troposphere and Stratosphere in Radio Ranging Satellites,” in *Geophysical Monograph Series*, mar 1972, pp. 247–251.
- [3] M. Bevis, S. Businger, T. A. Herring, C. Rocken, R. A. Anthes, and R. H. Ware, “GPS meteorology: remote sensing of atmospheric water vapor using the global positioning system,” Ohio State University; Massachusetts Institute of Technology, Tech. Rep. D14, 1992
- [4] H. Hersbach et al. ‘The ERA5 global reanalysis’, *Q. J. R. Meteorolog. Soc.*, vol. 146, no. 730, pp. 1999–2049, Jul. 2020.