

Sensibility of Dorne Margolin Chokinging Antennas to Rainfall

Analysis of a Sprinkled Antenna Site on a Short-Baseline

Introduction

Currently **station-dependent errors** are intensively studied, which cover **antenna phase variations**, **near-field effects** on GNSS antennas and general multipath effects. Near-field effects affect the antenna reception characteristic and are caused within the close vicinity of the antenna. The effect basically belongs to the multipath errors. The characteristic of the near-field effect, however, differs fundamentally, so that a separation from the **far-field multipath** effects is feasible and meaningful. Near-field effects have a long periodic behavior that have no zero mean characteristic and are therefore causing a systematic bias especially in the height component. Opposite to this, multipath far-field effects of phase measurements have a zero mean and can be eliminated or largely reduced with sufficient long observation times.

GNSS are generally **weather independent** with respect to the signal propagation in space. Rain, sleet or snow in the air between antenna and satellite will normally have no significant effect. Snow or ice, however, may accumulate on a GNSS antenna and absorb some of the GPS signals reaching the GPS antenna.

Multipath effects **depend on the reflective properties** of the environment and thus **depend on weather conditions**. With changing weather conditions a change in the position domain must theoretically be expected, if the acting errors are not effectively eliminated by the observation procedure or corrected in a sufficient way.



Chokerings during sprinkling



Typical draining of chokerings



Sprinkling of chokering antenna (station 0007)



Reference station 1000 with reflectors in the near-field



SNOW radome during sprinkling



View of short baseline (0011 and 0007) and reference station 1000 on flat roof

Motivation

What antenna setup should be used for **precise GNSS** applications?

- **Dorne Margolin type GNSS chokinging** antennas considered best choice

Is there any effect when it comes to rainfall?

- **drop forming** at the chokerings because of adhesion and cohesion
- **solid water** at the bottom of the chokerings

Is there any **advantage in using a radome** considering rainfall?

- **dry reception element** and chokinging from direct rain
- **drop forming** on radome
- **water layer** (or moisture) on radome

The **different reflective properties** of the environment on the stations at different weather conditions will individually affect the multipath influence. Consequently, **changes** in the characteristics of the receiving antenna occur which are visible in the **position domain**, when the differences are not considered in the processing.

The weather conditions over short distances in GNSS applications are generally comparable: it rains or it rains not on both stations. The situation is different in reference station networks. Already in RTK networks with intervals of 30 km in the spatial distribution of stations, but especially at intervals of several 100 km or more, exist completely different weather conditions on the GNSS stations. The same holds for extensive projects covering large areas (simultaneous use of a large number of receivers). An implicit elimination or reduction of similar acting error influences in differential GNSS processing is no longer valid due to the missing high correlation in such cases.

Setup of Experimental Investigations

- **three static stations**, 1-sec-data of 22 h length, JPS LEGACY receivers, observed on seven consecutive days (setup 1-7), basically comparable sidereal times
- **two identical pillars** and always the same equipment **setups** (0007 and 0011), **ASH700936D_M** antennas either both with **NONE** or with **SNOW radome**
- permanent Geo++ reference station 1000 (**control**), **ASH700936E SNOW** antenna with **single-sided pollution** of radome, strong **non-symmetrical near-field** multipath
- **reference coordinates** from **dry weather** conditions for all stations (☀ or ☀)
- **“rain simulation”** for **one single antenna** site (0007) (☔ or ☔) by using a lawn sprinkler with rainfall intensity of 21 mm/h
- **natural rainfall** on additional days for all stations (☁) with rainfall intensity of 3 to 4 mm/h at the rainy days
- four **absolute antenna calibrations**, combining all possible combinations of no radome, SNOW radome, **dry weather** and **“rain simulation”**

Hence, there is heavy rainfall in the controlled setup and moderate rainfall during the natural setup (5 mm/h moderate rainfall, 50 mm/h violent storms in Germany).

Analysis of Controlled Rainfall GNSS Measurements

In a **dual frequency** GNSS processing with **tropospheric scale factor** plane coordinates are estimated. These coordinate **differences between two days** are displayed below. Coordinate changes larger than 0.5 mm and due to rainfall are indicated in **blue**.

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
NONE	☀ 1 vs. 2	☔ 0011-0007	+0.0	+0.0	-0.1
SNOW	☔ 3 vs. 5	☔ 0011-0007	-1.1	+0.3	-2.9

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
NONE	☀ 1 vs. 2	☔ 1000-0007	-0.1	+0.0	+0.2
SNOW	☔ 3 vs. 5	☔ 1000-0007	-1.2	+0.3	-3.9

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
NONE	☀ 1 vs. 2	☔ 1000-0011	-0.2	+0.0	+0.3
SNOW	☔ 3 vs. 5	☔ 1000-0011	+0.0	+0.0	-0.4

Setup with no radome (NONE)

- **no significant changes**

Setup with radome (SNOW)

- **coordinate changes** in height component of -3 to -4 mm
- **even coordinate changes** in horizontal component

It is noteworthy that the horizontal coordinate component, and in this experiment the east component, is affected. Due to the experimental setup and the implementation of the lawn sprinkler in the eastern part of the pillar there is a single-sided influence on the antenna suspected.

The control setups with the continuously operated reference station 1000 and reference station 0011 (completely dry) show neither for the baseline without radome nor for the baseline with radome significant coordinate changes.

Analysis of Additional Measurements

Comparisons of antenna setups with SNOW radome and **changing weather conditions** with different periods of natural rainfall and intensity show

- **no coordinate changes** from the weather conditions (0007 and 0011) as long as the **station setups are identical** and the stations are **affected in the same way**
- **coordinates changes up to 5 mm** from weather conditions (1000) due to **near-field effects** and **at random** due to times of rainfall and different satellite geometry

Setup 7 shows larger differences, because the observation period is much shorter and the satellite constellation has changed the most.

Coordinate changes larger than 0.5 mm and due to near-field are indicated in **red**.

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
SNOW	☔ 4 vs. 5	☔ 1000-0011	-0.2	+0.0	+0.1
SNOW	☔ 6 vs. 5	☔ 1000-0011	+0.0	-0.3	+3.1
SNOW	☔ 7 vs. 5	☔ 1000-0011	-1.2	+0.9	+4.7

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
SNOW	☔ 4 vs. 5	☔ 1000-0007	-0.4	+0.3	+0.2
SNOW	☔ 6 vs. 5	☔ 1000-0007	-0.2	-0.3	+2.8
SNOW	☔ 7 vs. 5	☔ 1000-0007	-1.4	+1.2	+3.5

Radome	Setup	from-to	dE [mm]	dN [mm]	dh [mm]
SNOW	☔ 4 vs. 5	☔ 0011-0007	-0.1	+0.0	-0.2
SNOW	☔ 6 vs. 5	☔ 0011-0007	-0.1	+0.0	-0.4
SNOW	☔ 7 vs. 5	☔ 0011-0007	-0.1	+0.3	-0.9

Analysis of Controlled Rainfall during Absolute Antenna Calibration

The results of the absolute antenna calibration confirm the investigation of the static experiments. While comparing sprinkled and dry calibrations

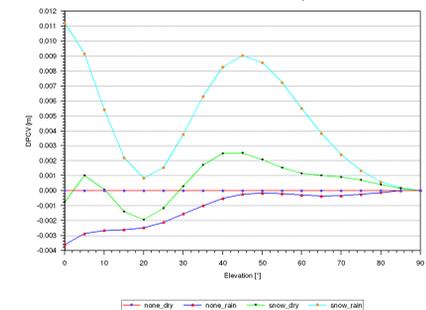
- **small PCV changes** (significant compared to repeatability of individual antenna) and especially **change in height offset** for the calibration **without radome**
- **significant PCV changes up to 10 mm** and change in height offset for the calibration **with SNOW radome**



Sprinkling of chokering antenna with SNOW radome during antenna calibration

Elevation Dependent Difference referenced to ARP

ASH700936E NONE SN: CR16978, LO PCV



Influence sprinkling chokering antenna with and without SNOW radome during antenna calibration for LO DPCV [mm]

Summary

There are significant effects from rainfall identified on the coordinate determination of a 22 hour long sprinkled chokinging antenna with radome. The influence of a heavy rain on the height component for the investigated antenna model Ashtech ASH700936D_M SNOW is 3 to 4 mm. This means that systematic effects in precise height determination are present between antennas with and without radome or between antennas with radome in case of differences in local moisture and rain fall.

The additional, not controlled setups regarding rainfall confirm the identified coordinates changes. In addition the control station with strong not symmetrical reflectors in the near-field of the antenna reveals significant coordinates changes under changing weather conditions.

The detected changes are also found in other applications with shorter observation time. In the experiment, the more far-field multipath has been eliminated through long observation times. In case of short observation times the identified effects on antenna reception characteristics will be superimposed by multipath.

Further analysis is required (rain intensity, polluted water, different antennas and radomes, etc) to complete the findings.