LONG BASELINE GNSS RELATIVE POSITIONING
WITH ESTIMATING IONOSPHERIC AND TROPOSPHERIC
DELAYS AND THEIR GRADIENTS

YUKIHIRO KUBO, HISAYA TANAKA, MASAHARU OHASHI AND SUEO SUGIMOTO
Department of Electrical and Electronic Engineering
Ritsumeikan University
1-1-1, Noji-Higashi, Kusatsu City, Shiga 525-8577, Japan
ykubo@se.ritsumei.ac.jp

Received March 2011; revised July 2011

ABSTRACT. In the long baseline GPS (Global Positioning System)/GNSS (Global Naviga-
tion Satellite System) relative positioning the ionospheric and tropospheric delays are
dominant factors for the positioning accuracy. In this paper, we present Real Time
Kinematic (RTK) relative positioning algorithms for long baselines with simultaneously
estimating ionospheric and tropospheric delays and their gradients. Also some dynamical
models [1-3] of the rover station are reviewed for applying Kalman filters, and we show
the experimental results of relative positioning for various baselines (short, medium, long)
by using the Gps Earth Observation NETwork (GEONET) data provided by Geospatial
Information Authority (GSI) of Japan.

Keywords: GNSS regression models, Ionospheric delay, VTEC, GEONET, Orthogonal
polynomials

1. Introduction. The GNSS relative positioning is one of the positioning methods which
can provide most precise relative position between a receiver at a known point (reference
station) and a receiver at a unknown point (rover station). In general relative position-
ing method, the unknown position is estimated by using so-called double differences of
pseudorange and carrier phase measurements obtained by the receivers [4, 5].

Generally, the dominant error sources of the estimated unknown position are the iono-
ospheric and tropospheric delays of waves from satellites. However, if the distance between
the receivers is not so long (generally less than 20 [km]), they can be canceled out by
applying the double differencing technique because the propagation paths of the waves
can be assumed to be almost the same, so that the ionospheric and tropospheric delays
also can be assumed to be almost the same.

On the other hand, the double differencing technique is no longer effective for the
medium and long baselines (more than 20 [km]) positioning due to large differences of the
ionospheric and the tropospheric delays between the reference and rover GNSS receiver
stations. For long baseline positioning, it is extremely important to obtain accurate
information of the ionospheric and tropospheric delays in order to achieve rapid and
accurate positioning results. Therefore, in this paper we propose the long baseline relative
positioning algorithms with simultaneously estimating the ionospheric and tropospheric
delays and their gradients at the reference and rover stations as the state variables in the
Kalman filter.

In our previous research [6, 7], for the tropospheric delays, we have applied the formula
which expresses the total tropospheric delay as the sum of the zenith hydrostatic and
wet delays multiplied by mapping functions. Then we assume that the zenith hydrostatic