Terrain Moisture and stream Level for Integrated Reflected GPS System using Reflectivity and Elevation Map

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Biographies

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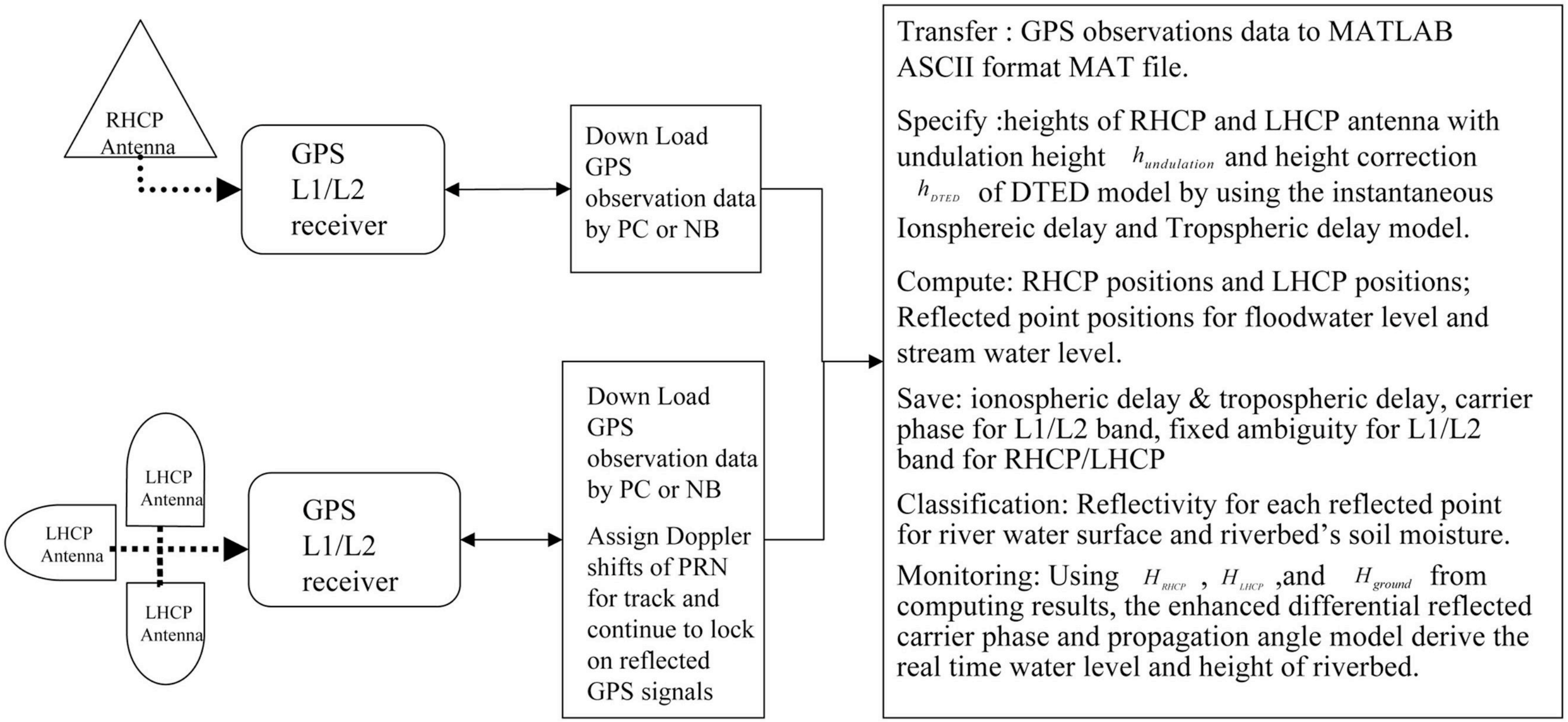
content

abstract

- a new application and development of a highly integrated GPS receiver with reflected GPS signals for ocean state and sea tide will be described.
- The precise point positions for RHCP and LHCP antennas are enhanced and processed by repeating instantaneous ionosphere delay correct model with deriving from L1 and L2 carrier phase and troposphere estimated parameter model.
- For remote sensing of ocean, the accuracies of each reflected sea level are among 10 cm and 30 cm.
- Soil moisture classification is improved by approximately 75~80% by using correction factor and multispectral (reflectivity) data along with normalization surface roughness parameters.

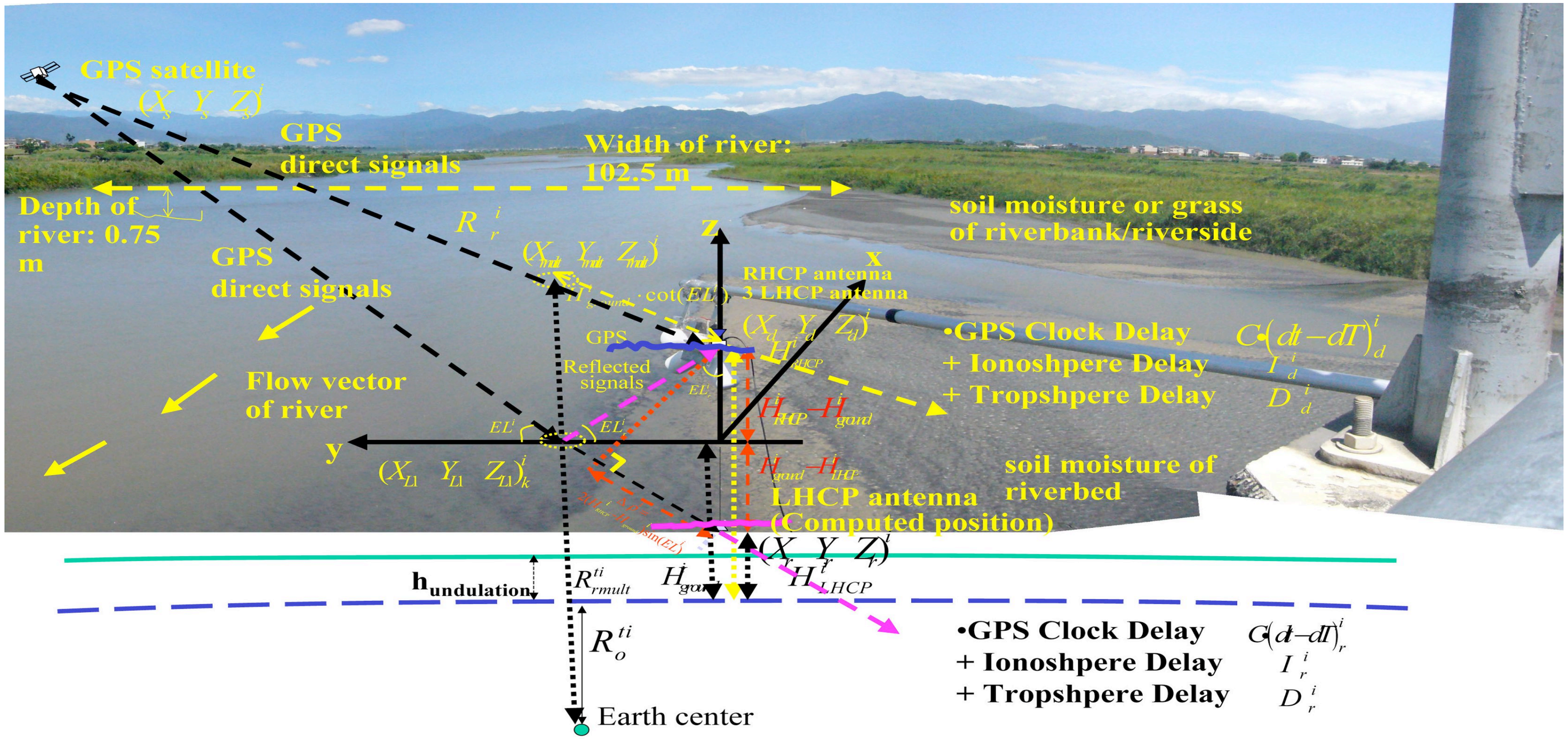
INTRODUCTION

- The system diagram for remote sensing of stream water level and soil moisture of riverbed are shown as Figure.



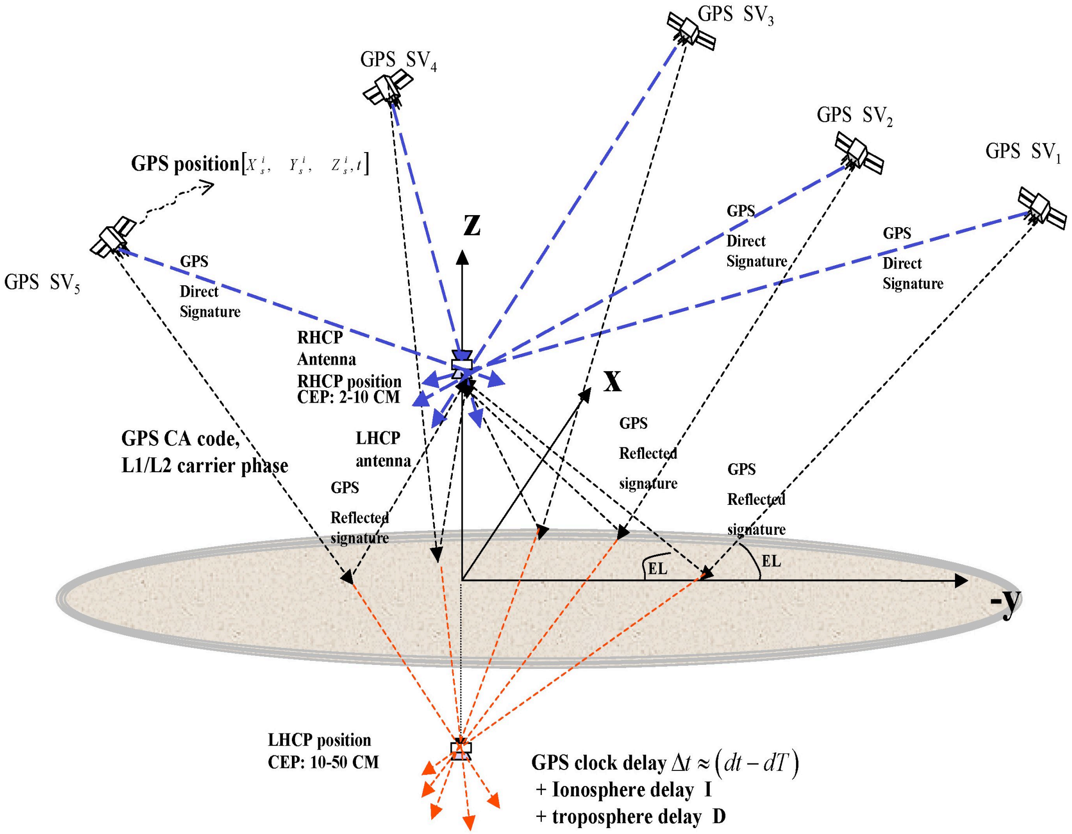
INTRODUCTION (cont.)

- The instrument is mounted on a 6.5-meter-length of steel pipe with one RHCP and three LHCP antennas by using two GPS L1/L2 Band receivers. The height of the antennas is 10.5 meters between LHCP antenna and referenced to stream water level at Lan-Yang River, Taiwan.



METHODOLOGY(I)

- A least-squares searching algorithm for LHCP receiver position was enhanced and developed by centimeter level altitude loop (Goad, 1997) as follows in the principal observation equation. the 3-D geometry of line of sight between Receiver position on Taiwan and five reflected GPS signals generators satellites show as Figure.



$$\Phi_{1s} = R_s + \mathrm{C}\left(\mathrm{dt} - \mathrm{dT}\right)_{\mathrm{s}} - I + T + \lambda_1 N_{1s} + \varepsilon_{\phi 1s}$$

$$\Phi_{2s} = R_s + \mathrm{C}\left(\mathrm{dt} - \mathrm{dT}\right)_{\mathrm{s}} - I + T + \lambda_2 N_{2s} + \varepsilon_{\phi 2s}$$

s = d: Direct signal;

s = r: Reflected signal.

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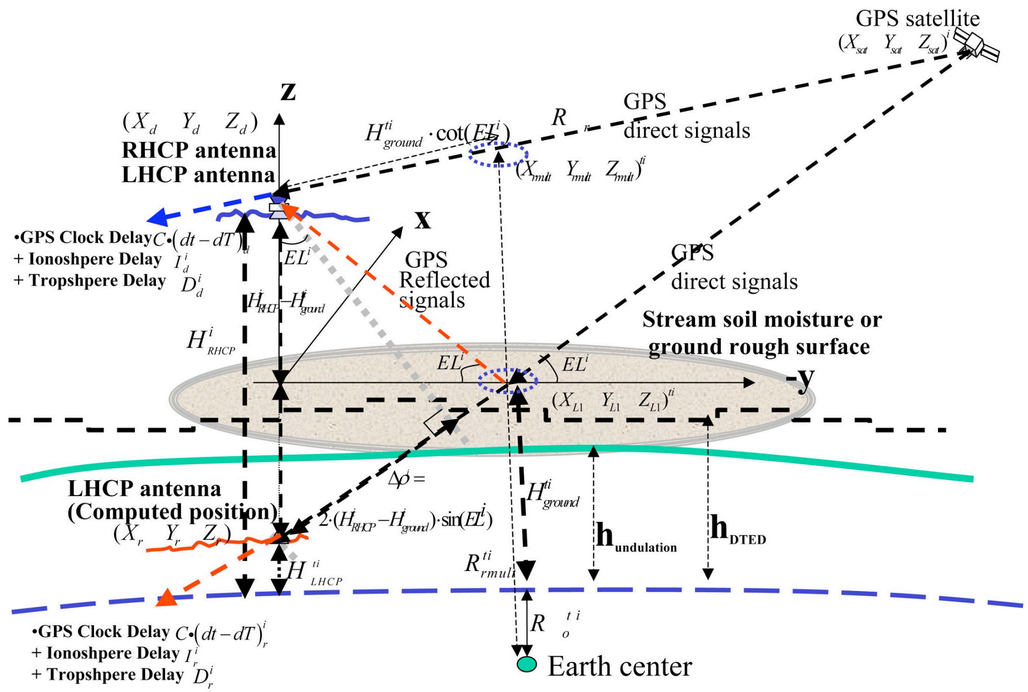
METHODOLOGY(II)

- the Stream water level of local height and reflected foot print are described as following in two Equations. The Profile of Reflected Ground surface position and GPS satellite position: show as :

$$H^{i}_{ground} = \frac{(H^{i}_{RHCP} + H^{ti}_{LHCP})}{2} - h_{undulation}$$

$$\begin{bmatrix} X_{L1} \\ Y_{L1} \\ Z_{L1} \end{bmatrix}^{ti} = \left[\frac{R^{ti}_{o} + H^{i}_{ground}}{R^{i}_{rmult}} \right] * \begin{bmatrix} X_{rmult} \\ Y_{rmult} \\ Z_{rmult} \end{bmatrix}^{i}$$



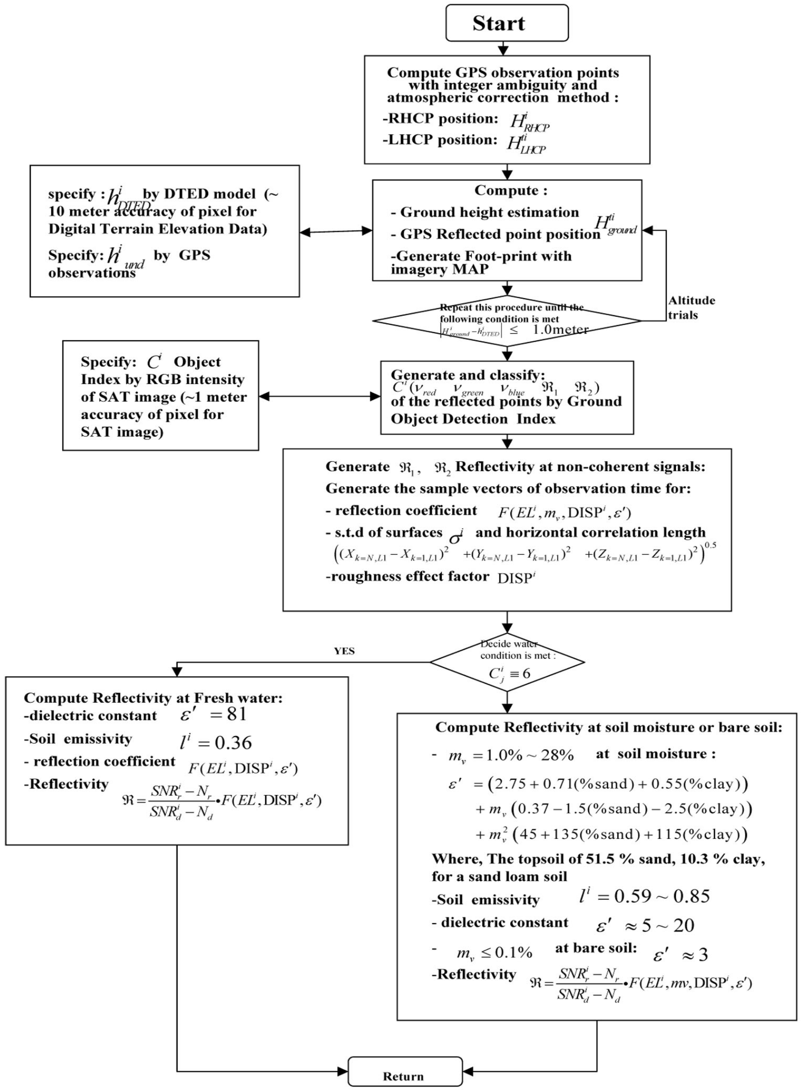
$|H^{ti}_{ground} - h^{i}_{DTED}| \le 1.0 \quad meter$

METHDOLOGY(III)

- The processing diagram of the Coastal sea level of local height and reflected foot print show as Figure. The altitude trial procedure repeats until the following condition is met as $|H^{ti}_{ground} - h^{i}_{DTED}| \le 1.0 \quad meter$.
- The reflectivity and Normalization roughness surface parameter of simulation program are described as following in two Equations.

$$\Re = \frac{(\mathrm{SNR})_r - N_r}{(\mathrm{SNR})_d - N_d} \cdot F(EL, m_v, \mathrm{DISP}, \varepsilon')$$

$$\mathrm{DISP} = \frac{\text{standard deviation of } H_{ground}}{\text{length of reflected footprint}}$$

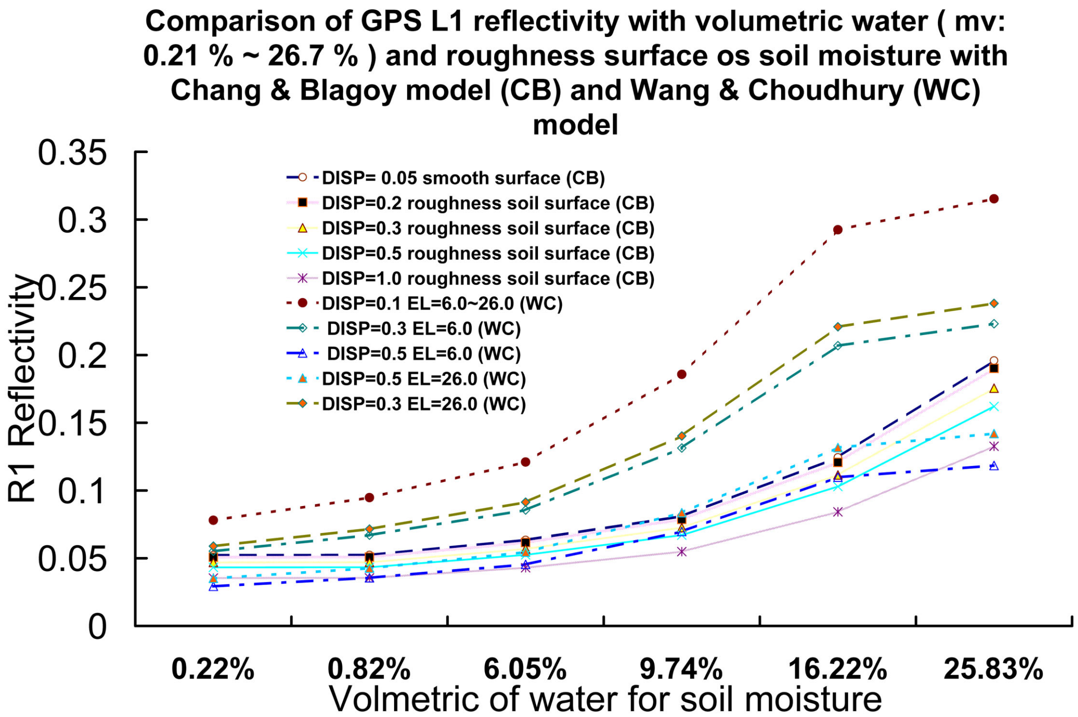


METHDOLOGY(IV)

- ***Soil moisture and roughness surface Model:*** The reflectivity at rough surface and soil moisture results are presented by Chang & Blagoy model and Wang and Choudhury model as following Eq. (shown as Figure)

$$\Re = \frac{(\mathrm{SNR})_r - N_r}{(\mathrm{SNR})_d - N_d} \cdot F(EL, m_v, \mathrm{DISP}, \varepsilon')$$

$$\Re = (1-Q)\Re_H + Q\Re_V = \frac{1-l}{\exp(4k^2\sigma^2\cos^2(EL))}$$



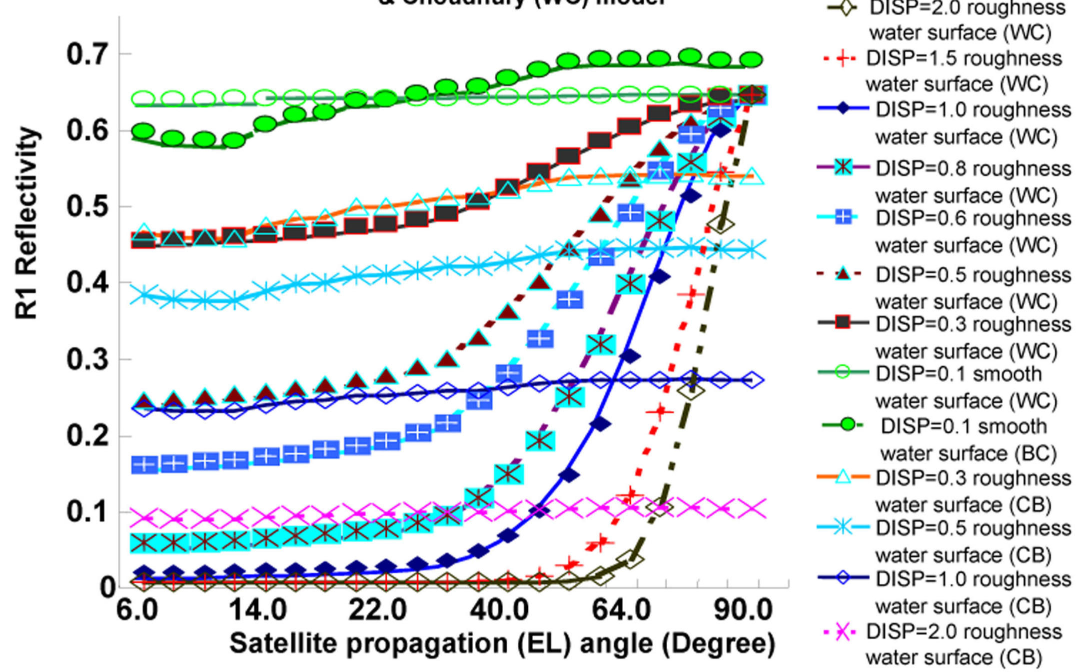
METHDOLOGY(IV)

- ***Stream water and Propagation Angle Model:*** The reflectivity at rough surface and soil moisture results are presented by Chang & Blagoy model and Wang and Choudhury model as following Eq. (shown as Figure)

$$\Re = \frac{(\mathrm{SNR})_r - N_r}{(\mathrm{SNR})_d - N_d} \cdot F(EL, m_v, \mathrm{DISP}, \varepsilon')$$

$$\Re = (1-Q)\Re_H + Q\Re_V = \frac{1-l}{\exp(4k^2\sigma^2\cos^2(EL))}$$

Comparison of GPS L1 reflectivity with satellite propagation angle (EL= 6 ~ 90 Deg) and roughness surface of fresh water with Chang & Blagoy (CB) and Wang & Choudhury (WC) model



RESULTS(1)

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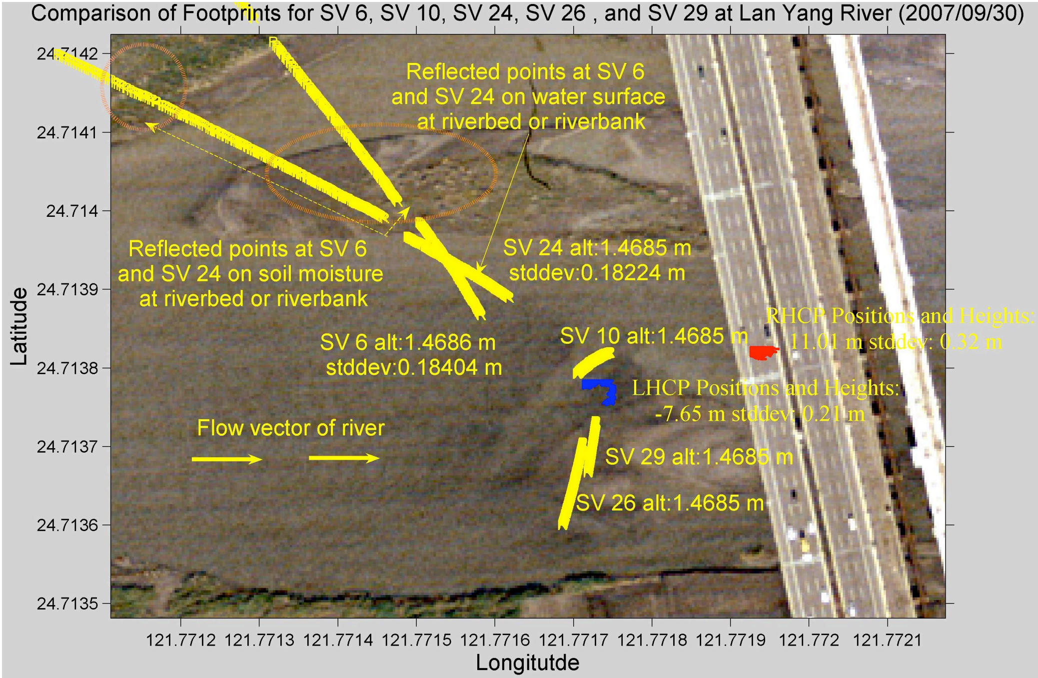
- ***Reflected Points Results :*** The measure and altimetry elevation for stream water level and soil moisture of riverbeds through out the reflected GPS signals at different location was described as Figure. The reflected area of stream and soil of riverside were made and described. (UTC Time 2007 09 30 23 35:01-24 35:20 UT (7:35- 8:35 am LT)) The combined water surface reflected points and highly resolution (~ 50 cm of pixels) image for PRN 6, 10, 24, 26, and 29. .



RESULTS (2)

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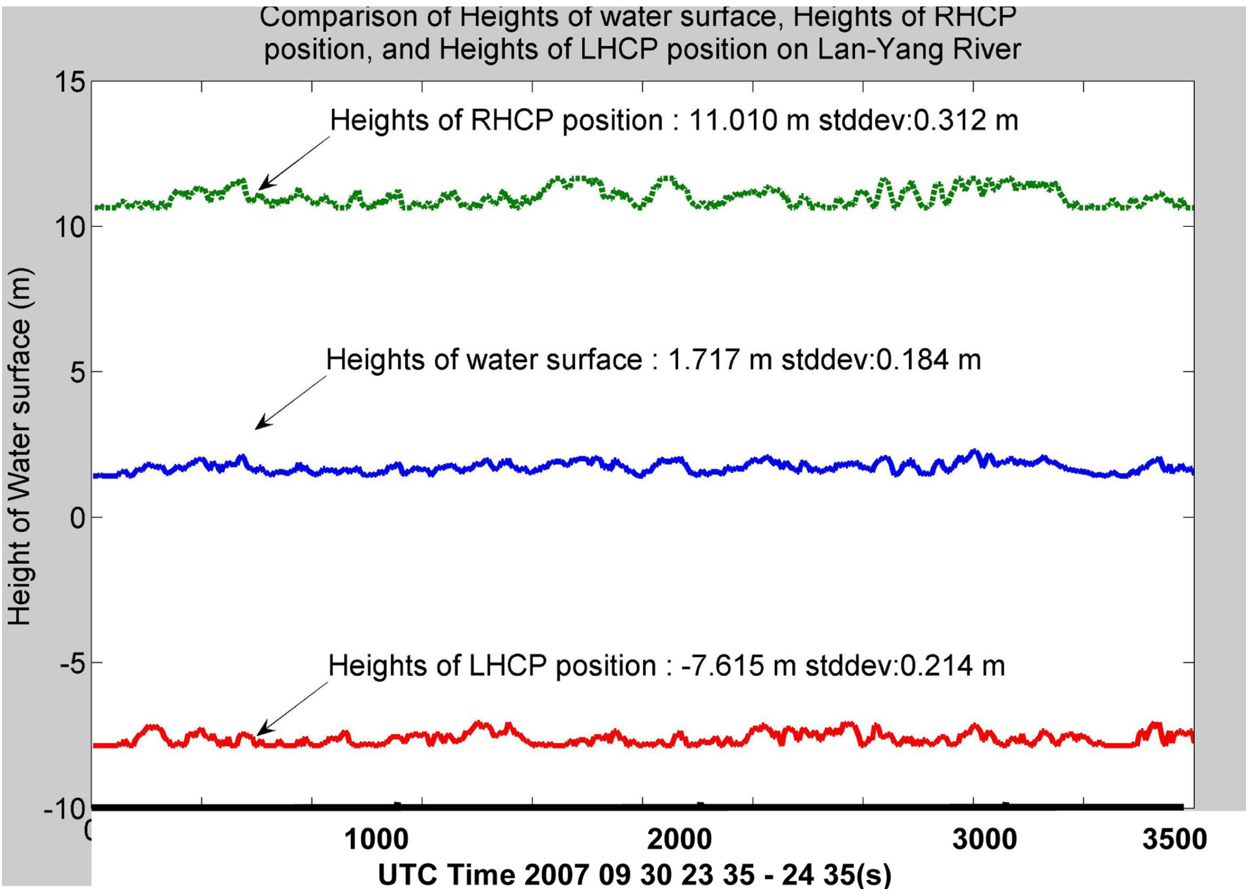

- Comparison analyses of stream water level, RHCP antenna altitude, and LHCP antenna altitude on Lan-Yang River, Lan Yang and each altitude with correction of $h_{undulation} \approx 20.2\, meters$.

RESULTS(3)

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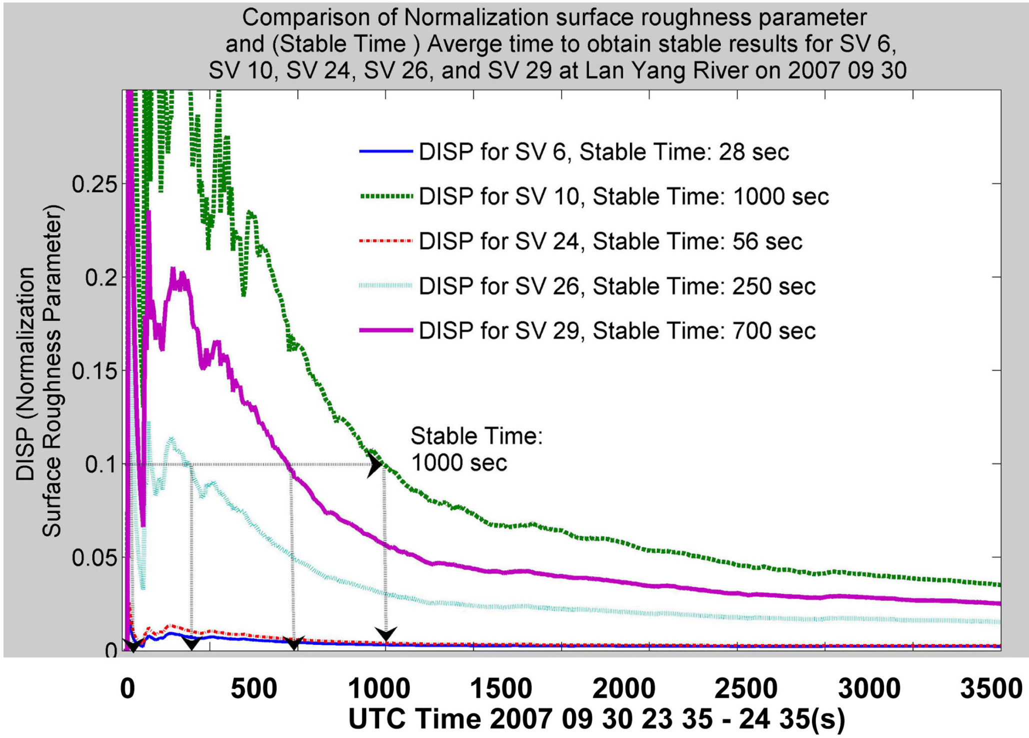
- The average of time to obtain a stable results is 45 sec at normalization surface roughness parameter for PRN 6 and PRN 24 on the propagation angle $EL^i = 6.5^o \sim 25.0^o$. The average of time to obtain a stable results is 650 sec at normalization surface roughness parameter for PRN 10, PRN 26 and PRN 29 on the propagation $EL^i = 25.0^o \sim 72.0^o$ show as Figure. .



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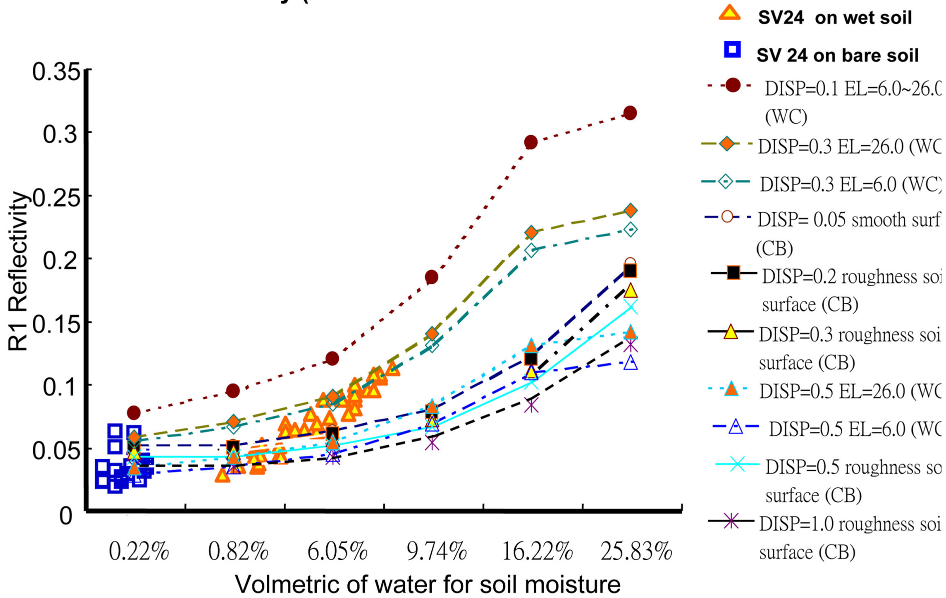
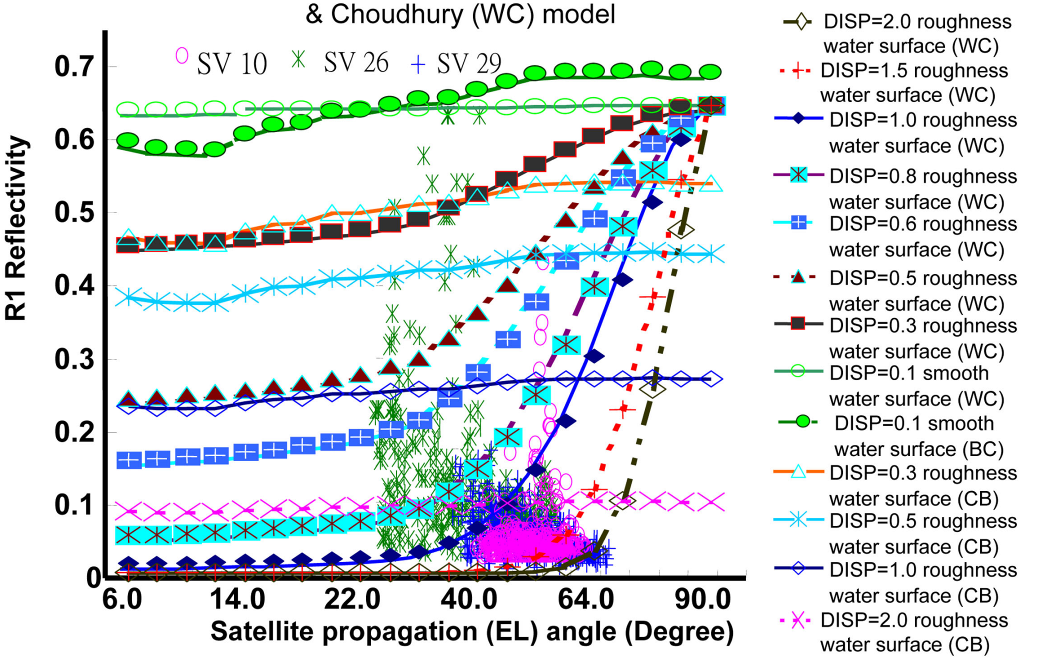
RESULTS(4)

Comparison of GPS L1 reflectivity for SV 24 and reflectivity with volumetric water (mv: 0.22 % ~ 25.83 %) and roughness surface for soil moisture with Chang & Blagoy model (CB) and Wang) & Choudhury (WC model



Comparison of GPS L1 reflectivity with satellite propagation angle (EL= 6 ~ 90 Deg) and roughness surface of fresh water with Chang & Blagoy (CB) and Wang & Choudhury (WC) model



A comparison of reflectivity vs. soil moisture and surface roughness for measurements at Lan-Yang River (PRN 24). The reflectivity $\Re_1^{24} = 0.05 \sim 0.10$ from stream soil moisture with roughness surface and volumetric water (: 0.82 % ~ 8.5 %) of soil moisture and the reflectivity $\Re_1^{6} = 0.01 \sim 0.07$ from bare soil on riverside with roughness surface and volumetric water (: < 0.4 %) of soil moisture. **a comparison of** $\Re_1^{i} = 0.01 \sim 0.65$ **reflectivity vs. other propagation angle (**$EL^{i} = 25.0^{o} \sim 72.0^{o}$ **) and surface roughness water for measurements at Lan-Yang River (PRN 10, PRN 26, and PRN 29)** showed as Figure .

Conclusions

- It has shown that the accuracy performance of the developed algorithms exhibits robustness with respect to the GPS L1/L2 signature distributions for stream water, soil moisture of riverbeds, bare soil of riversides, and the fluctuation of reflection on roughness surface.
- This algorithm could be used for the recovery of reflectance spectra from stream soil moisture measurements and remote sensing of flood flow.
- It was found that the classification accuracies was improved about 75~80 % by using the multi-spectral (reflectivity) data coupled with roughness surface parameters.
- **Authors issue that is the subject for future research is the optional choice of flood or flood plain boundary at storm weather.**
- **This paper can guarantee optimum performance in estimating soil moisture classification and stream water level.**

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