Atmospheric Remote Sensing Using GNSS in the Australasian Region: From Temperate Climates to the Tropics

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1. INTRODUCTION

Water vapour is part of the Earth's atmosphere and it is crucial for meteorological processes. Improved knowledge of the water vapour field is vital for understanding the atmospheric radiation, hydrological cycle and climate system. Moreover, many global meteorological phenomena such as tropical storms, El Niño and La Niña require information on the regional and global spatial (in 3-dimensions) and temporal variability of the atmospheric water vapour. The Global Positioning System (GPS) is a useful and economical tool for the remote sensing of atmospheric water vapour. The GPS signals propagate through the Earth's atmosphere and due to neutral molecules in the troposphere layer, the signals are delayed and refracted. There are essentially two types of GPS-based atmospheric remote sensing techniques: ground-based techniques and satellite-based radio occultation techniques.

The trend in the establishment of GPS Continuously Operating Reference Stations (CORS) creates a unique opportunity not only for positioning applications, but also for ground-based GPS *Meteorology* [1]. The total delay or Zenith Path Delay (ZPD) can be extracted from the GPS signals after a careful data processing. Together with surface pressure and temperature data, the Integrated Water Vapour (IWV) can be inferred from the estimated ZPD – a useful quantity for meteorological applications. Ground-based GPS meteorology projects such as WAVEFRONT (Water Vapour Experiment For Regional Operation Network) in Europe, MAGIC (Meteorological Applications of GPS Integrated Column Water Vapour Measurement) in the Western Mediterranean, GASP (GPS Atmospheric Sounding Project) in Germany, and GPS Meteorology in Japan, have consistently demonstrated that atmospheric water vapour can be estimated to an accuracy commensurate with existing measurement techniques such as water vapour radiometers and radiosondes [1]. In addition, the CORS are relatively inexpensive to setup and operate, and provide higher spatial and temporal resolution.

GPS radio occultation (RO) is a very promising atmospheric remote sensing technology. Approximately 2,500 global daily GPS RO events (ROEs) can be obtained as a result of the launch of the six COSMIC (Constellation Observing Systems for Meteorology, Ionosphere, and Climate) low Earth orbit satellites in April 2006. COSMIC satellites are equipped with GPS receivers, and the analysis of ROEs provides information on both tropospheric and ionospheric parameters. Over 100 of these daily ROEs from COSMIC can be retrieved over Australasia, which represents ten times more observations in comparison with the (single satellite) CHAMP mission. The planned new satellite launches in the next few years by countries in South America, Europe and Asia will offer opportunities for geodesists to address critical issues such as climate changes, weather monitoring, cyclones, and drought and environmental problems in general, through satellite-based atmospheric remote sensing techniques, complemented by CORS-based approaches. Furthermore, the opportunity to study the active atmosphere in tropical areas (ionosphere and troposphere) over the coming years is extremely exciting.

2. AUSTRALASIAN STUDIES

Research groups in Australia and Malaysia are cooperating in a number of GPS meteorology projects. This paper discusses the challenges of atmospheric remote sensing in the Australasian region, which stretches from the temperate zones (at latitudes as far south as 45degree) to the equator, and presents some preliminary outcomes. The ZPD estimates from two CORS networks – the Sydney CORS network (SydNET) in the temperate zone, and the Malaysian Real-Time Kinematic network (MyRTKnet) in the tropics – have been obtained. Moreover, the IGS (International GNSS Service) stations were included in the ZPD estimation process so as to provide an opportunity to assess the estimated ZPD against the IGS-derived troposphere products. From these ZPD values, animations of ZPD time series were generated within the network coverage through an inverse distance weighting interpolation method. This is valuable information for a variety of climate and weather research applications.

GPS RO results from CHAMP and COSMIC over two years (from July 2006 to March 2008) have been obtained, and were evaluated using both numerical weather prediction models and radiosonde data. Studies show that GPS RO derived Earth's atmospheric profiles agree well with both modelled data and radiosonde observations in general in Australasia across different geographic areas (e.g. low, mid and high latitude regions), and provide useful information on the spatial and temporal error characteristics of the GPS RO data for a number of different scenarios (e.g. seasonal performance).

3. EXPERIMENTAL RESULT

Preliminary result of the ZPD interpolation (Figure 1) shows higher magnitude ZPD is found in the tropics, especially in South-East Asia, Brazil and northern Australia. Study by [2] also confirmed that South East Asia always have higher magnitude ZPD during the monsoon periods. This indicates that research should be focused in this area. Participation of CORS networks from this area plays a very important role in support of GPS meteorology. In addition, more CORS will provide better ZPD estimation and therefore benefit both global and local scientific and meteorlogical communities in this area.

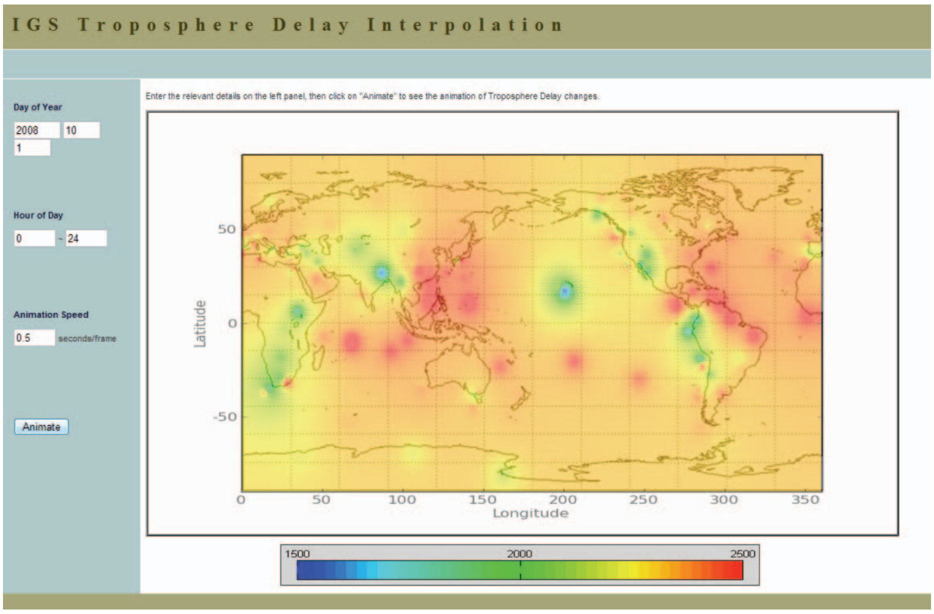

Figure 1: ZPD map as interpolated from IGS troposphere product

4. CONCLUDING REMARKS

Challenges for Australia & Malaysia:
1. To collaborate in producing near real-time IWV and other troposphere products using as many real-time data streaming CORS as possible.
2. To establish a online GPS Meteorology data processing centre that services the region, from the tropics to temperate climates of Australia.
3. To encourage other countries within the focus area to participate in GPS Meteorology studies by providing access to real-time CORS data to reserachers.

5. REFERENCES

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