Densification and Autonomization of Geodetic GPS Stations in Southern California Capable of Producing Tropospheric Delay and Precipitable Water Vapor Measurements

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1. How we get precipitable water vapor from ground GPS (the basics)
2. A few examples of GPS integrated WV in Southern California weather
3. SIO-JPL-Caltech-NOAA project to generate NRT GPS IWV onsite

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Permanent GPS in Southern California
Precipitable Water from GPS

\[ \Delta t_{\text{total}} = \Delta t_{\text{geom}} + \Delta t_{\text{iono}} + \Delta t_{\text{trop}} + \ldots \]

In solving for this, we estimate this

\[ \text{Zenith hydrostatic delay} = f(\text{surface pressure}) \]

\[ \text{Zenith wet delay} \]

\[ \text{Total trop delay} \]

\[ \text{Mapping functions} \]

\[ \text{PD}(\theta) = ZHD \cdot mh(\theta) + ZWD \cdot mw(\theta) \]

\[ \text{PW} = \kappa \times ZWD \]

\[ 1/\kappa = 10^{-6} \times \rho R_v [(k_3/T_m) + k_2'] \approx 6.5 \]

Mean atmosphere temp

\[ \Rightarrow \text{With a surface pressure and a surface temperature, we get to PWV from ZTD.} \]
Monsoon Progression in California

Pre-monsoon

Monsoon onset

Peak monsoon

July 13, 2007
06Z

July 14, 2007
00Z

August 1, 2007
21Z

Slide credit: Jim Means/UCSD
GPS WV documents Oct 2007 Santa Ana
Real-time GPS in southern CA

• Dense enough to envision using NRT WV for monitoring monsoon/Santa Ana/AR conditions
NASA AIST-11 project

(1) Autonomous, power-efficient, low-cost, plug-in geodetic module for existing GPS stations for data fusion of *in situ* sensors including GPS (GNSS), strong-motion accelerometers, and meteorological instruments (pressure and temperature)

(2) Generation of on-the-fly higher-order data products including millimeter-level displacements and precipitable water within the geodetic module

(3) Enabling autonomous sensors to communicate with central nodes through the geodetic module to allow for control functions, data, data product, model exchanges, and alarming

(4) Technology infusion

Slide credit: Y. Bock/UCSD
Proposed 27-station prototype network
Project collaboration

• PI: Yehuda Bock, UCSD Scripps Institution of Oceanography
• JPL & Caltech
• NOAA ESRL – Technology infusion partner
• NOAA NWS WFOs Los Angeles/Oxnard and San Diego – Technology infusion partners
First steps

• increased the number of stations contributing to the NOAA ESRL GPS-Met observing network in southern California by about 27, decreasing the 12Z ZTD by roughly half (WV uncertainty now about 2.5mm)

• LOX forecasters began utilizing WV via ESRL’s web page during the 2012 North American monsoon season, finding it to be an effective tool for evaluating model performance
ESRL GPSMet web interface used by forecasters
Next steps

• Prototype accelerometer package is coming soon; prototype met package is next
• Installation of Geodetic Module + onsite sensors at 27 station network
• Work toward onsite calculation and transmission of IWV
• Further development of forecaster use of GPS IWV