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# Alternative Strategy for Estimating and Monitoring Satellite Water Vapor Observation Errors

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## Introduction

As discussed by Andersson et al. 2007, "The lack of absolutely calibrated humidity data makes dealing with biases in observations and model(s) one of the main issues for determining the global moisture distribution and a balanced hydrological cycle." To date, two approaches to the problem of absolute (i.e. with respect to SI standards) calibration of satellite radiance measurements have been proposed: in situ and precise post-launch vicarious calibration (PPVC). The in situ method utilizes suitably transformed reference radiosonde (GRUAN (GCOS-134) or SUAN (Reale, 2004) soundings coordinated with satellite overpasses to calibrate/validate satellite observations and derived products. The PPVC technique requires us to launch a "calibration observatory (into Earth orbit) that can be used to calibrate a variety of space-borne sensors and thereby improve to climate accuracy a wide range of sensors across the earth observing system (NRC, 2007)."

The need for this type of capability was recognized by the climate research community in the 1990's. It was subsequently embodied in the Global Space-based Inter-Calibration System (GSICS) proposed by WMO and the Coordination Group for Meteorological Satellites (CGMS) in 2005, called for in the ASIC3 Report (Ohring et al. 2007) and explicitly realized in the NASA CLARREO mission that was cancelled when it was cut from the FY 2012 NASA budget.

This poster presents an alternative strategy to estimate satellite water vapor observation errors and monitor the performance of operational satellite sensors in the absence of SI Traceable observations from CLARREO.

## Proposed Strategy

| Observing System | Function | Applications | Notes |
|---|---|---|---|
| GNSS satellites in HEO (**Fig 1**) | Transmit radio signals in two or more frequencies | • Active remote sensing sys/seg<br>• PNT(Positioning, navigation, timing)<br>• Atmospheric remote sensing<br>• Hydrology | Next generation Block III GPS Satellite. In addition to GPS, the GNSS constellation will include GLONASS, Galileo and other international satellites |
| Radio Occultation receivers on notional COSMIC II satellites in LEO (**Fig 2**) | Receive GNSS signals as the LEO's rise and set behind the limb of the Earth., and then transmit range and phase observables to data processing centers around the world | • Passive remote sensing sys/seg<br>• Space Wx<br>• Climate<br>• Wx prediction<br>• Satellite IR & MW Cal/Val<br>• UA sounding verification<br>• Model verification | Data processing centers estimate the location and trajectory of the limb sounding, estimate bending angle and refractivity as a function of altitude, retrieve geophysical parameters and transmit the data to Sat Cal/Val & EM Centers, & derived products to forecasters |
| GNSS receivers on offshore platforms far (>40km) from shore (**Fig 3**) | Receive GNSS signals from all satellites in view and transmit range and phase observables to data processing centers around the world | • Passive remote sensing sys/seg<br>• Space Wx<br>• Climate<br>• Wx prediction<br>• Radar altimeter Cal/Val<br>• Satellite MW Cal/Val<br>• Model verification | Data processing centers estimate the ionospheric and tropospheric signal delays and transmit the data to Sat Cal/Val & EM Centers, and derived products to forecasters |
| GNSS receivers at fixed locations on land (**Fig 4**) | Receive GNSS signals from all satellites in view and transmit range and phase observables to data processing centers around the world | • Passive remote sensing sys/seg<br>• Space Wx<br>• Climate monitoring/model verification<br>• Wx prediction<br>• Satellite IR Cal/Val<br>• UA sounding QC | Data processing centers estimate the ionospheric and tropospheric signal delays and transmit the data to Sat, RAOB Cal/Val & EM Centers, and derived products to forecasters |
| GCOS Upper-Air Network (GUAN) sites in red, and GCOS Reference Upper-Air Network (GRUAN) sites (**Fig 5**) | Launch conventional rawinsondes from GUAN sites and reference radiosondes from GRUAN sites around the world | • Improved quality control and observation error descriptions from GUAN sites.<br>• Essential QC for reference radiosonde upper-air moisture and temperature soundings | In this strategy, ground-based GNSS receivers are located at all GRUN and GUAN sites around the world. |
| Operational GNSS Tracking Network (**Fig 6**) | Provide an assured source of real-time high temporal resolution GNSS observations from tracking stations funded, operated & maintained by UN members under international agreement | • Assured source of reliable real-time GNSS at no cost and without restriction for global PNT applications | Operated on behalf of the international community by the International GNSS Service (http://igscb.jpl.nasa.gov/) |

Fig 1

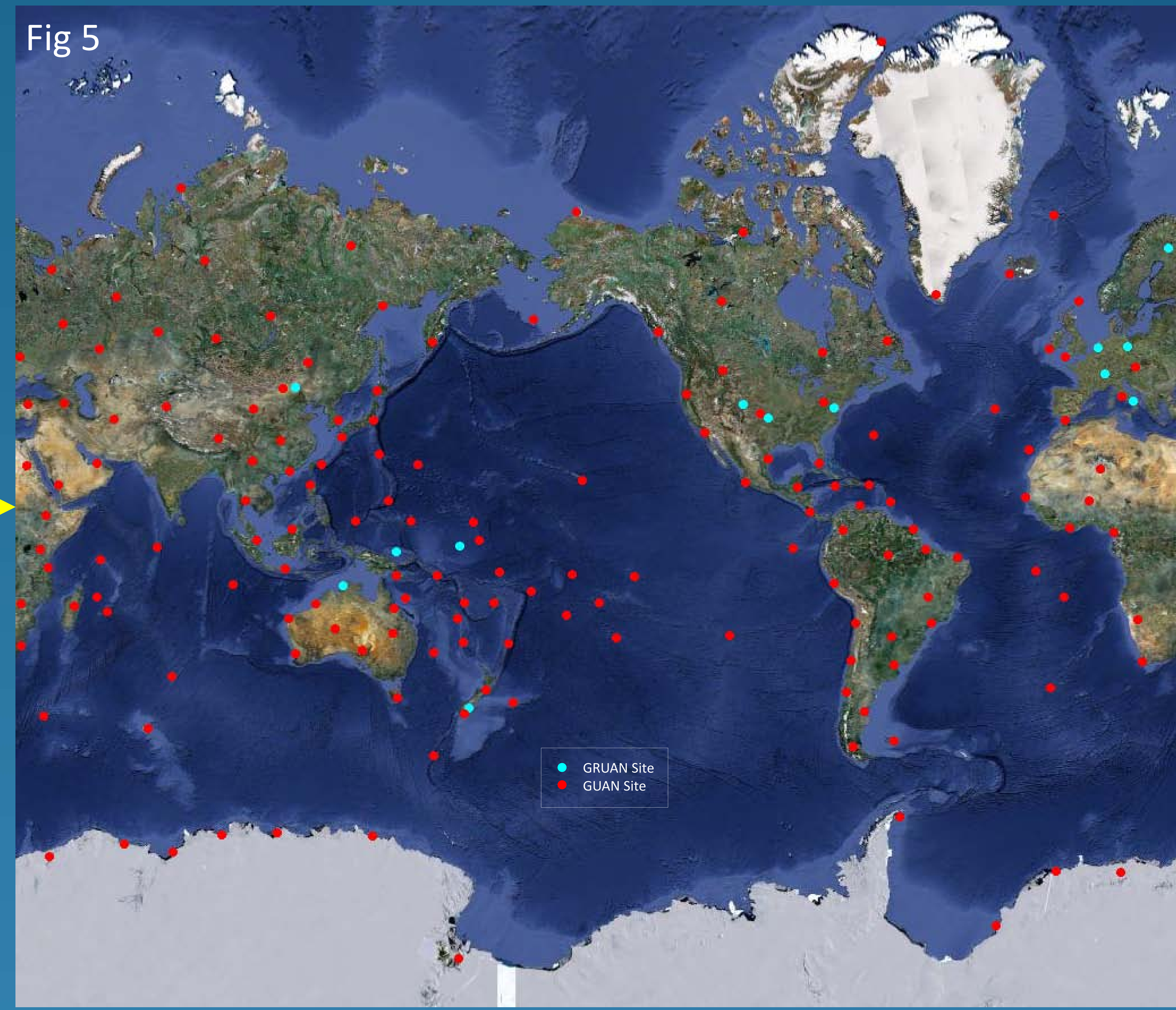

Fig 5


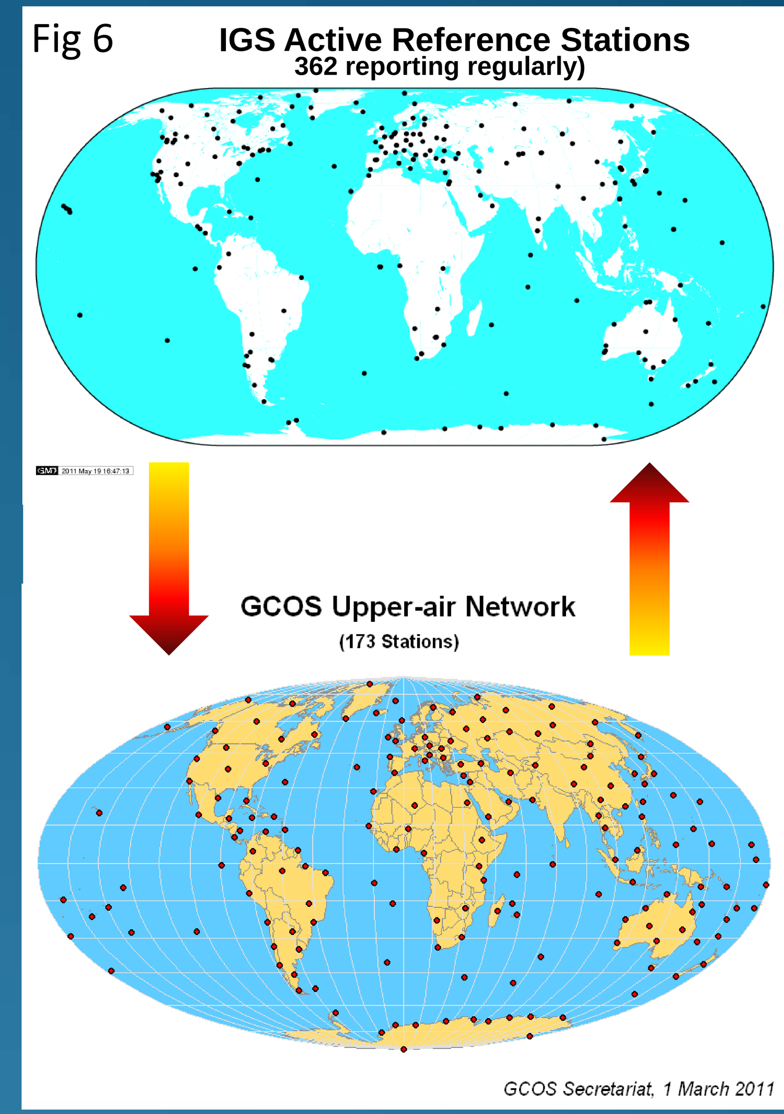

Fig 6


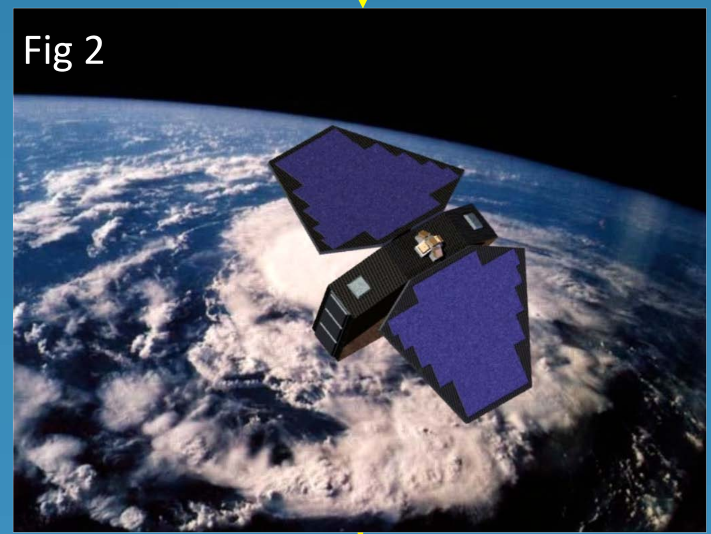
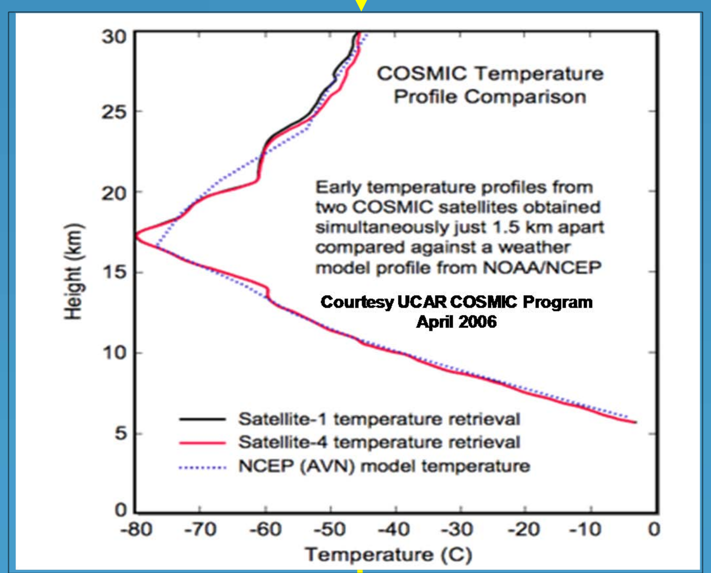
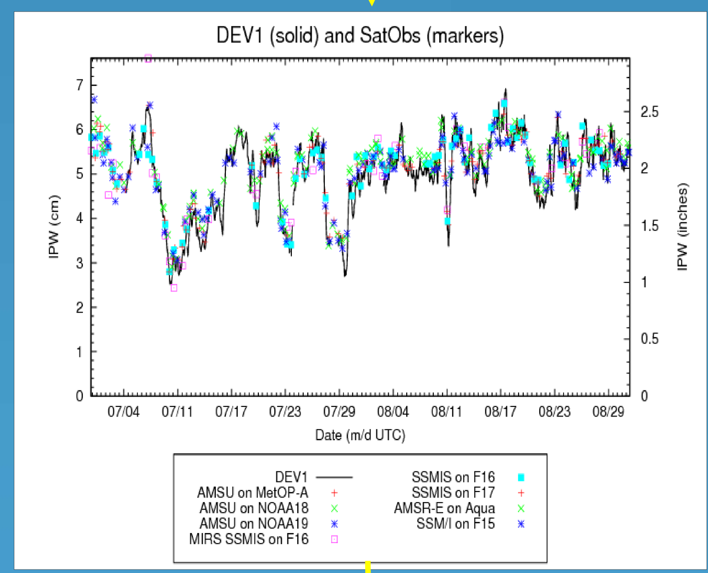
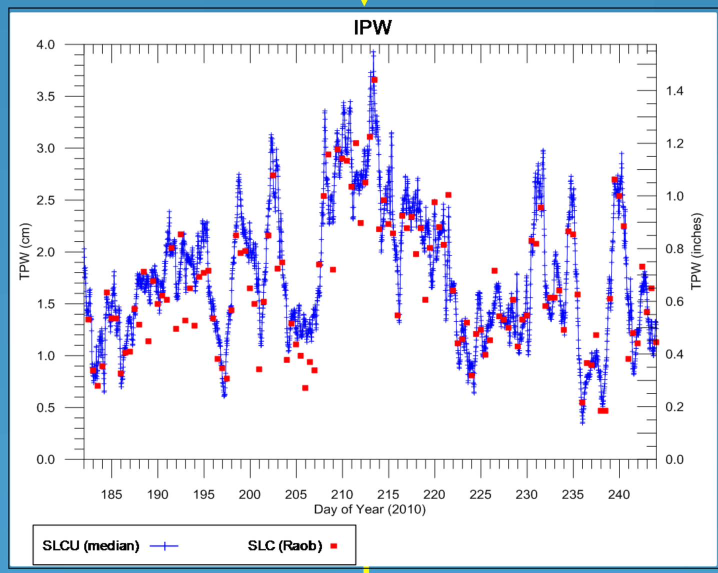

Fig 2


Fig 3


Fig 4


### Continuous Global Observations

- Cal/Val satellite sounder observations & products
- Verifying *in situ* & ground-based remote sensing measurements
- Assimilation into atmospheric models
- Climate monitoring
- Verifying climate model predictions

### Continuous Marine Observations

- Continuous monitoring of microwave & IR sounder characteristics free of surface-emissivity induced errors
- Observation error specification
- Independent verification of model background errors & model error covariance
- Independent evaluation of model bias corrections

### Continuous Land Observations

- QC of operational radiosonde moisture soundings
- Bias corrections for radiosonde & model profile radiance estimates
- Identification of systematic errors in GRUAN moisture soundings
- Transfer of UA observation error specifications from GRUAN to GUAN

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