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# *Weather and Space Weather Impacts for Users of GPS Radio Occultation*

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*Presented by James G. Yoe  
NWS/NCEP*

*Joint Center for Satellite Data Assimilation (JCDSA)  
Material Contributed by NCEP's Environmental Modeling  
Center and Space Weather Prediction Center  
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# Overview



- Why GPS?
- GPSRO Benefits
  - Numerical Weather Prediction (NWP)
  - Space Weather Monitoring and Prediction
  - Impacts of signal in adjacent bands
- Summary





# Why GPSRO?

- Assumption – Familiar w/GPSRO Method
- Two Applications/Areas of Impact
  - Numerical Weather Prediction
  - Space Weather Monitoring and Prediction
- Both Benefit from Key GPS Characteristics
  - Precision and stability of signal
  - Low-bias for accurate products
  - System resilience
    - Multiple sources and receivers





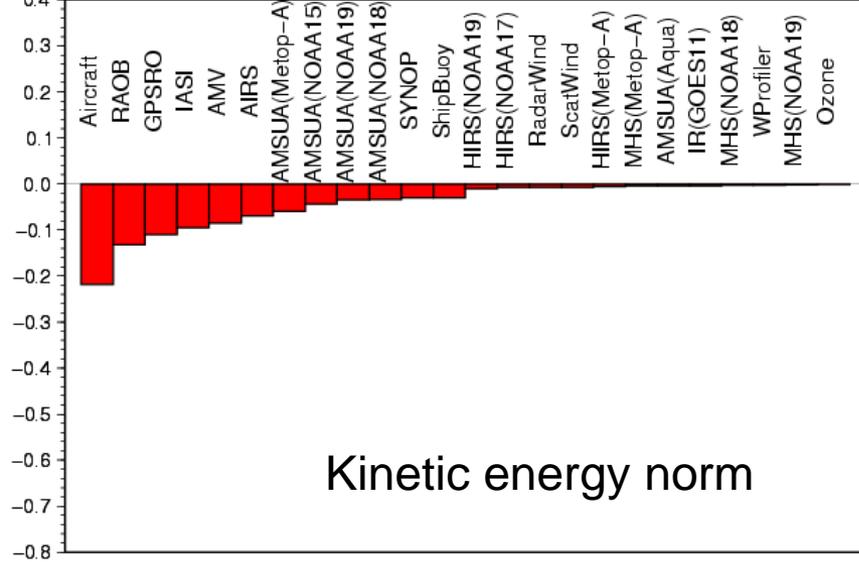
# GPSRO Benefits

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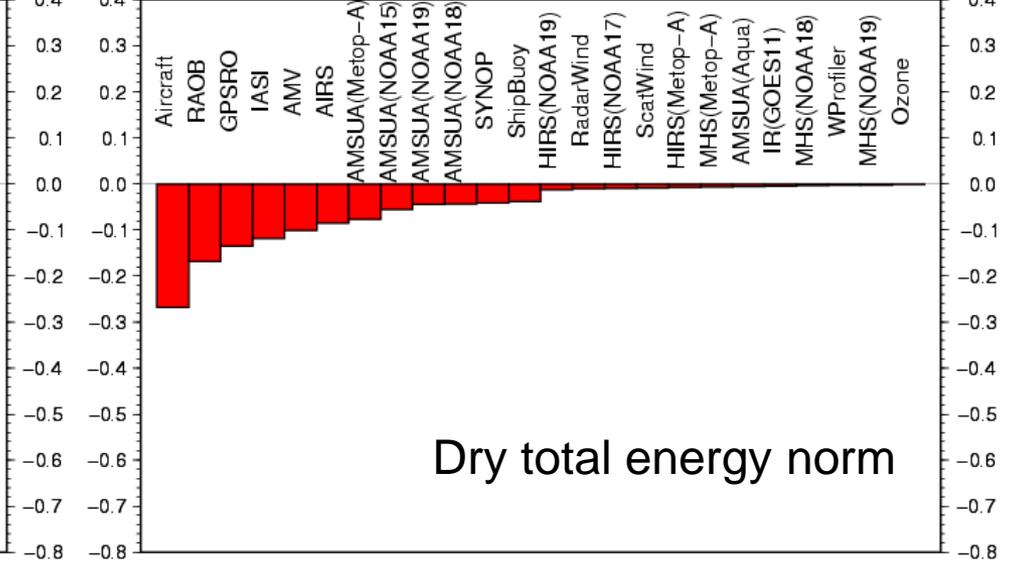
# NWP Observation impacts with various norms

Total observation impacts in 1 cycle [kinetic energy, J/kg]



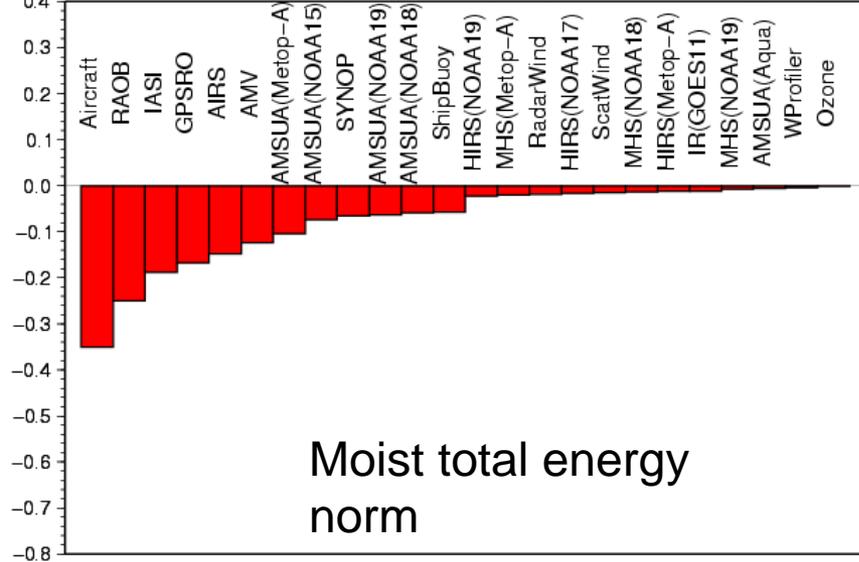
Kinetic energy norm

Total observation impacts in 1 cycle [dry total energy, J/kg]



Dry total energy norm

Total observation impacts in 1 cycle [moist total energy, J/kg]



Moist total energy norm

Accuracy, low-bias, and high vertical resolution of GPSRO soundings render them among the largest contributors to NWP forecast skill; GPSRO data complement and constrain other operational satellite sounders (both microwave and infrared); All-weather global distribution.

**Serial EnSRF**

# GPSRO for Space Weather

Space weather (ionosphere) imposes the largest errors and service interruptions for many GPS users as well as loss of HF communication

- Industries impacted by ionospheric storms:
  - Airline navigation and communication
  - Agriculture and construction
  - Surveying, drilling, and mining
- System Vulnerabilities
  - FAA's Wide Area Augmentation System procedures can become unavailable during space weather storms
  - Precise Point Positioning (PPP) impacted
  - Scintillation can result in denial of service for any application – L1/L2/L5
  - HF communication can be degraded or lost anywhere on the globe

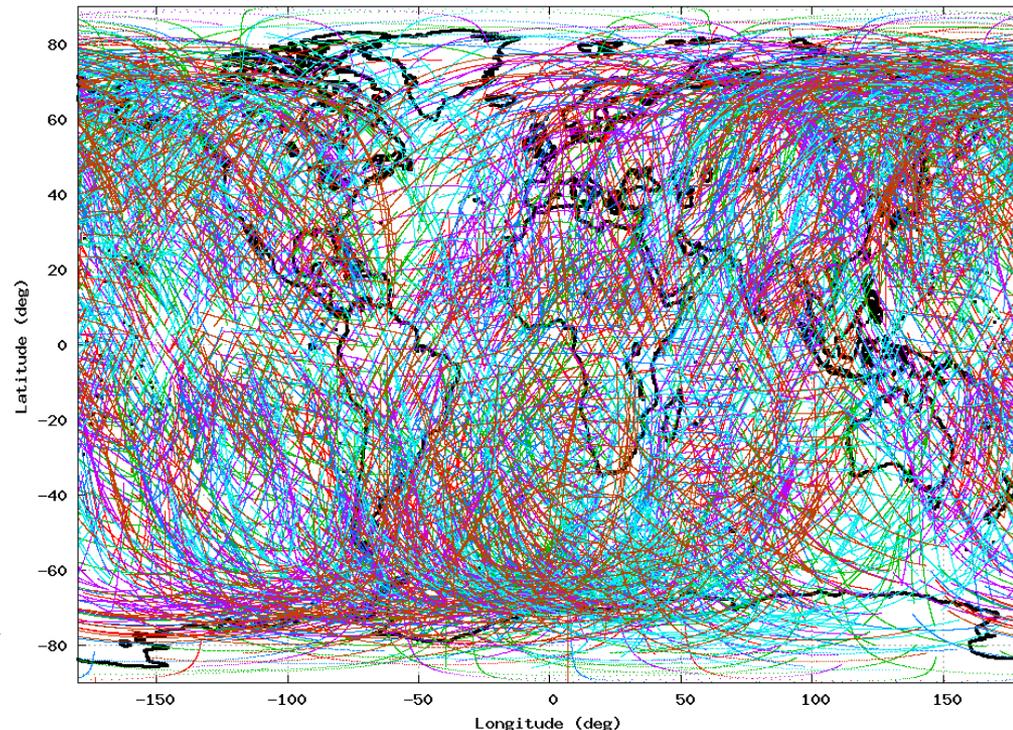


# GPSRO for Space Weather (cont'd)

Radio Occultation is the only technique to obtain uniform, global ionospheric measurements needed for space weather services

- Uniform global coverage over oceans and land
- Accurate measurement of vertical ionospheric profile
- Critical input to data-assimilation models of the coupled ionosphere-atmosphere system
- Forecasts and alerts of ionospheric disturbances support growing Positioning, Navigation, Timing, and Communication applications

COSMIC Measurements in 12 Hours





# Impacts



- Use of adjacent bands is expected to degrade GPSRO:
- Reduced SNR in certain geographic areas
  - Increase random noise introducing refractivity errors;
  - Decrease further the number of occultations reaching the surface; lose water vapor info
  - Mitigation by use of more restrictive filters likely to introduce systematic errors





# Summary

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- NWS and other operational users rely heavily on GPSRO
  - For NWP, Space Wx Monitoring/Prediction
- Use of adjacent bands likely to degrade RO
- Loss/degradation of GPSRO would be detrimental
  - Would hinder our ability to help protect lives, property, and economic activity

