



## CDR IN OPERATIONS

# Construction of Consistent Microwave Sensor Temperature Records and Tropopause Height Climatology using MSU/AMSU Measurements, GPS RO Data, and Radiosonde Observations

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# Outline

- 1. Short Project Description**
- 2. Production and QA Approach**
- 3. Concerns, Risks and Issues**
- 4. User Applications/Key Finding**
- 5. Schedule & Issues, CDR status/1-3 year planning horizon**

# 1. Product Description

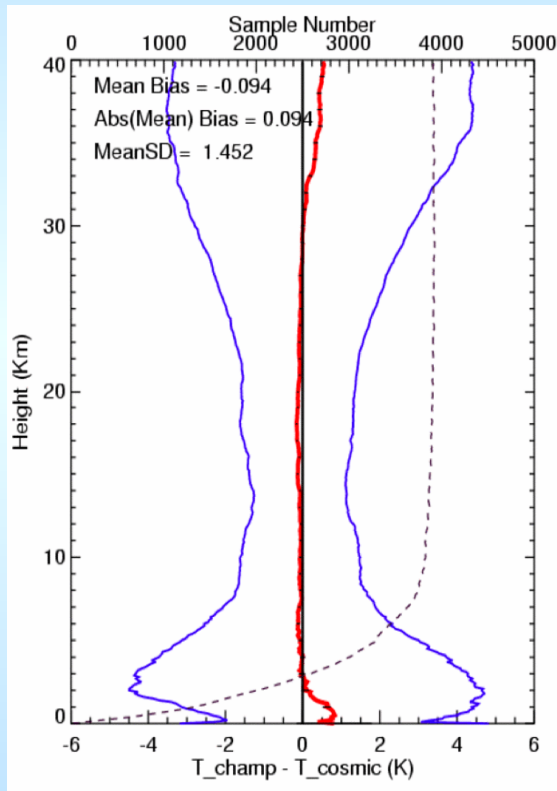
1. Quantify the pixel-level MSU/AMSU temporal and spatial temperature anomalies using GPS RO data from 2001 to 2012 TLS (temperature in the lower stratosphere :AMSU ch9, MSU ch4) and TTS (temperature in the troposphere and stratosphere: AMSU ch7 and MSU ch3)as climate benchmark datasets.
2. The ‘adjusted’ MSU/AMSU TLS/TTS data that were calibrated by multiple RO missions will serve as reference data to calibrate other overlapped MSU/AMSU data from 1978 to 2013. Those radiosondes that are consistent with RO profiles are used to calibrate MSU/AMSU measurements and the calibrated MSU/AMSU data will be used to calibrate other overlapped MSU/AMSU data.
3. To use GPS RO soundings collected from multi-RO missions to construct tropopause height climatology from 2001 to 2013.

# Product Delivery Description

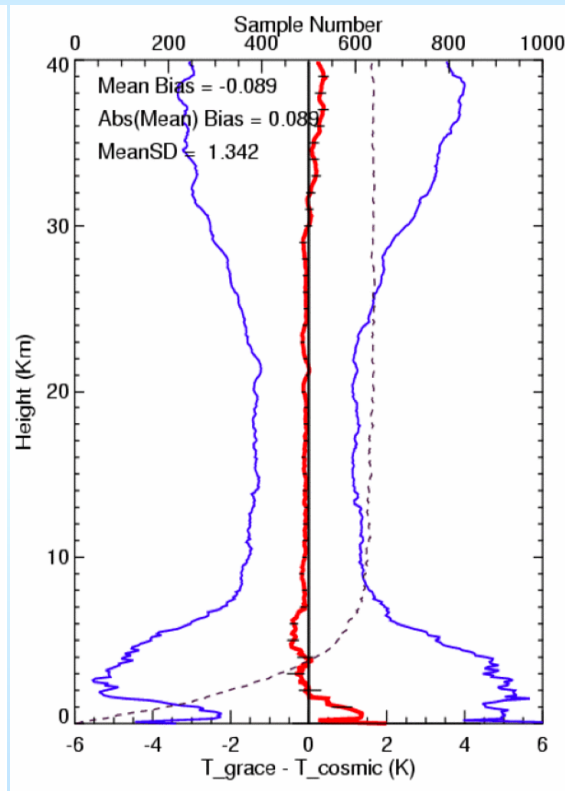
CDR(s)	Period of Record	Temporal Resolution	Update Frequency	Update Lag	Spatial Resolution	Data file distinction criteria	Do you publicly serve the CDR at your institution?
TLS (AMSU ch9 and MSU ch4)	From 1978 to 2012	Monthly Mean	Quarterly	One month	2.5x2.5 mean TLS	Time period (month), channel, and variables (i.e., TLS, TTS, Tropopause Height) are used to separate the data files.	Not currently
TTS (AMSU ch7 and MSU ch3)	From 1978 to 2012	Monthly Mean	Quarterly	One month	2.5x2.5 mean TTS		
Tropopause Height	From 2001 to 2012	Monthly Mean	Quarterly	One month	2.5x2.5 grid		

## 2. Validation & Quality Assurance (precision, accuracy and uncertainty)

### a. Global COSMIC, CHAMP, SAC-C, GRACE-A, Metop/GRAS Comparison Within 60 Mins, and 50 Km



CHAMP-COSMIC  
2007-2008



GRACE-COSMIC  
2006

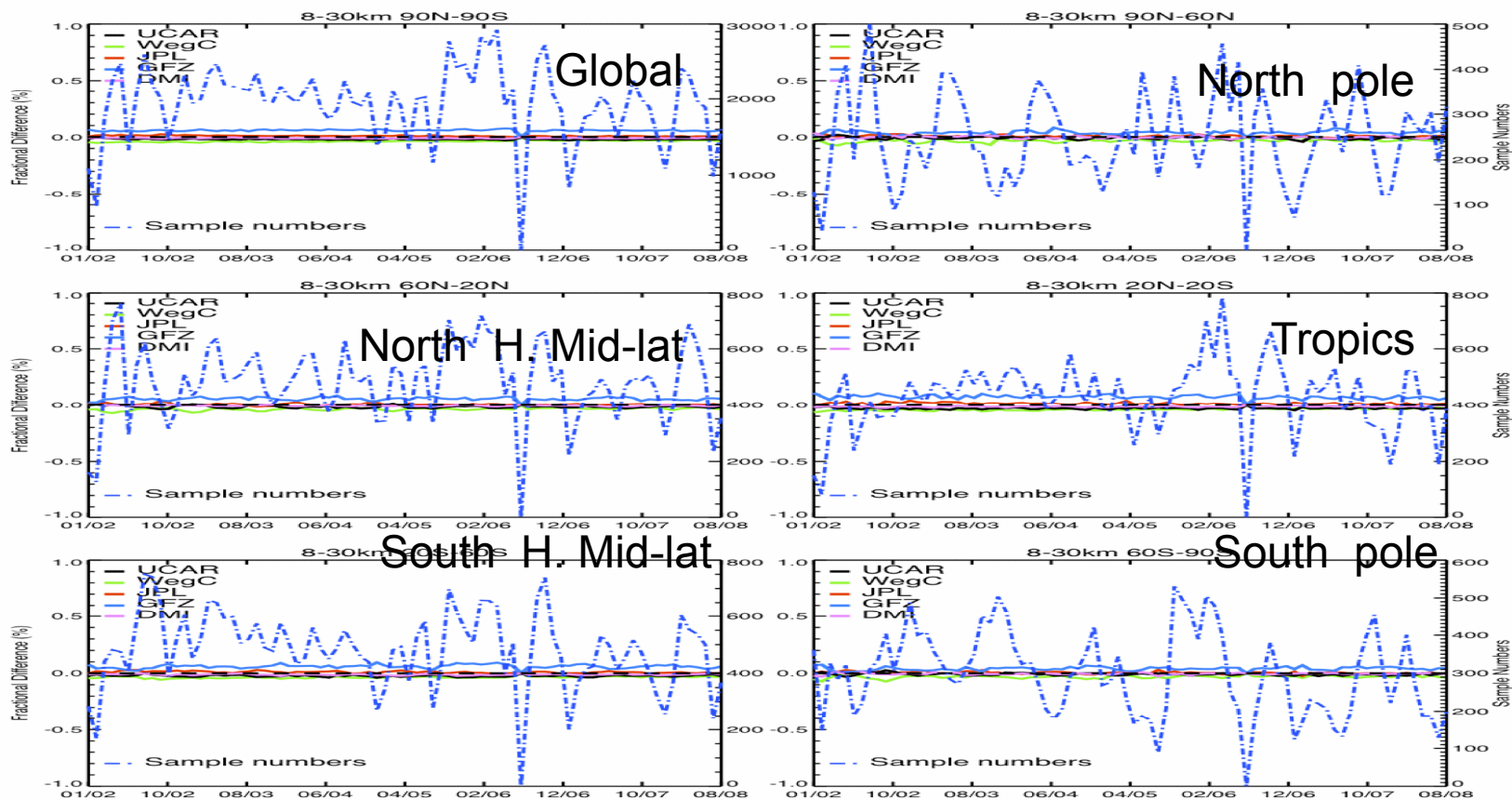
- Comparison of measurements between old and new instrument
- CHAMP launched in 2001
- COSMIC launched 2006
- GRACE launched 2002

Don't need to have stable calibration reference

Ho, S.-P et al., TAO, 2009, BAMS, 2010, JGR, 2010, 2012, 2013.

## 2. Validation & Quality Assurance (precision, accuracy and uncertainty)

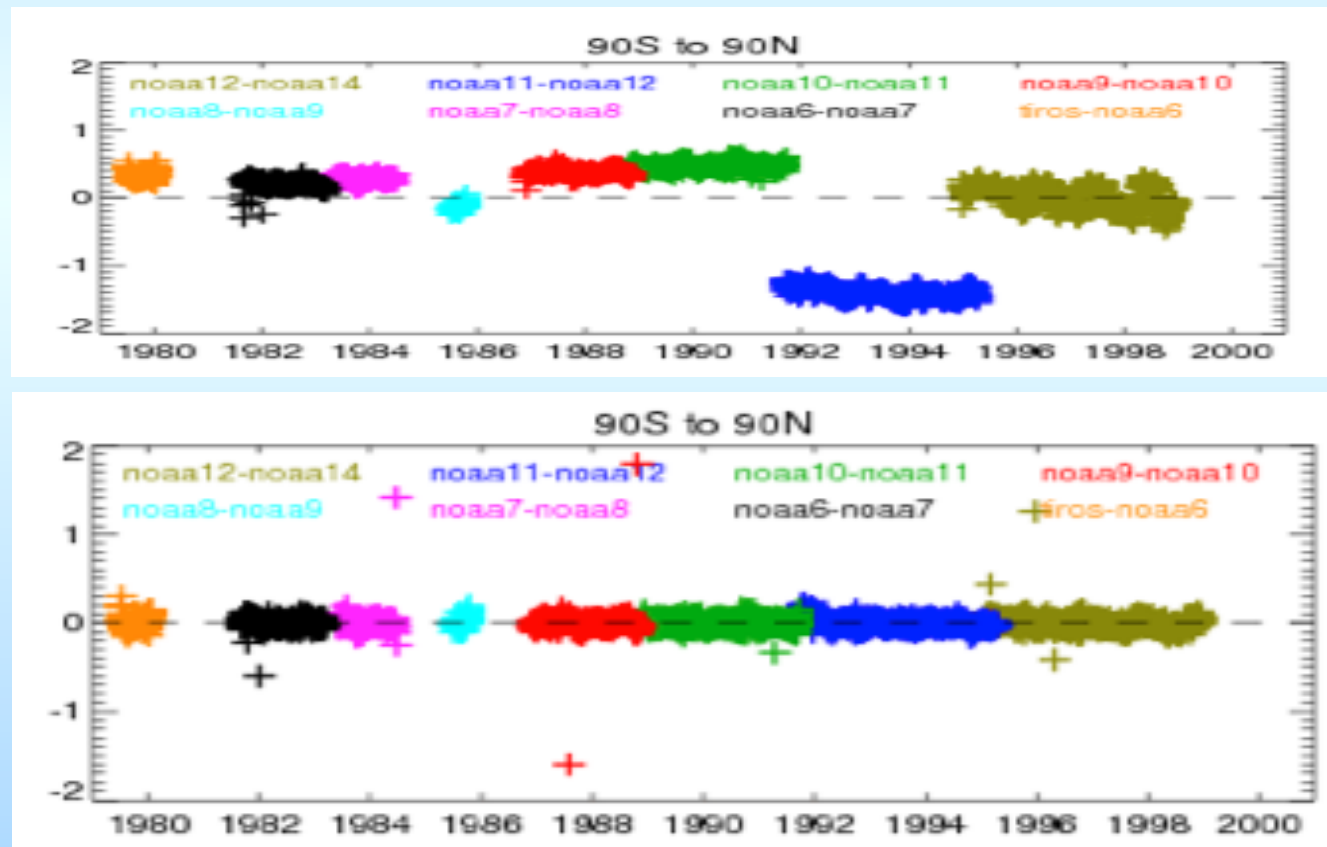
### b. Quantify the quality of RO data among different centers centers : reproducibility Ho, S.-P et al., JGR, 2010,2012, 2013.



8-30 km

## 2. Validation & Quality Assurance

- c. Describe how you assess product quality for each update period (e.g., day/week/month) used to extend the long term record : inter-satellite biases among missions



### 3. Concerns, Risks and Issues

- Describe any technical risks or issues that may jeopardize your sustained provision of the CDR(s) for the next 3 years (assuming funding is covered)
  - E.g., key retirements/graduations, loss of access to specialized resources, degrading satellite, etc.
  - Mitigation plan, if any
- **Upgrading the RO inversion algorithms for different RO missions : COSMIC, CHAMP, GRACE, SAC-C, Metop-A, Metop-B etc.**



## 4. User Applications

This proposed inter-satellite data comparison study will help to quantify systematic errors of temperature data records generated from multiple-platform and multiple-sensor satellite data obtained from international data providers, and improve their error estimates, which will enhance our understanding of important climate variation and processes.

Analysis from this study will help the science community, particular the climate science community, by improving

- i) Analysis: comprehensive of integrated climate products,
- ii) Assimilation: model initialization,
- iii) Reanalysis: improving the reprocessing of other data and re-analyses, and

-Blackwell W. J., Rebecca Bishop, Clayton Crail, Kerri Cahoy, Brian Cohen, Lidia Cucurull, Pratik Dave, Michael DiLiberto, Neal Erickson, Chad Fish, shu-peng Ho, R. Vincent Leslie, Idahosa A. Osaretin, Radiometer Calibration Using Co-located GPS Radio Occultation Measurements, *IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING*, 2013 (submitted).

Biondi\*, R., S.-P. Ho, W. Randel, T. Neubert and S. Syndergaard (2013), Tropical cyclone cloud-top heights and vertical temperature structure detection using GPS radio occultation measurements, *J. Geophys. Research*, VOL. 118, 1–13, doi:10.1002/jgrd.50448.

Biondi\*, R., W. Randel, S.-P. Ho, T. Neubert, and S. Syndergaard (2012), Thermal structure of intense convective clouds derived from GPS radio occultations, *Atmos. Chem. Phys.*, doi:10.5194/acp-12-5309-2012.

Steiner, A. K., D. Hunt, S.-P. Ho, G. Kirchengast, A. J. Mannucci, B. Scherllin-Pirscher, H. Gleisner, A. von Engel, T. Schmidt, C. Ao, S. S. Leroy, E. R. Kursinski, U. Foelsche, M. Gorbunov, Y.-H. Kuo, K. B. Lauritsen, C. Marquardt, C. Rocken, W. Schreiner, S. Sokolovskiy, S. Syndergaard, and J. Wickert (2013), Quantification of Structural Uncertainty in Climate Data Records from GPS Radio Occultation, *ACP* doi:10.5194/acp-13-1469-2013.

-Ho, S.-P., IPCC AR5 report (invited).

- Ho, S.-P., Y.-H. Kuo, X.-J. Zhou, P. Callaghan, 2011: The Use of the COSMIC/FORMOSAT-3 Global Positioning System Radio Occultation Data as Global Reference Observations in Orbit and Their Applications in Meteorology, *Horizons in Earth Science Research*, Vol. 5, B. Veress and J. Szigehy, Eds. NOVA Publishers, in press (invited).

- Scherllin-Pirscher\* B., C. Deser, S.-P. Ho, C. Chou, W. Randel, and Y.-W. Kuo, (2012), The vertical and spatial structure of ENSO in the upper troposphere and lower stratosphere from GPS radio occultation measurements, *Geophys. Res. Lett.*, 39, L20801, 6 PP., 2012, doi:10.1029/2012GL053071.

- Ho, S.-P., G. Kirchengast, S. Leroy, J. Wickert, A. J. Mannucci, A. K. Steiner, D. Hunt, W. Schreiner, S. Sokolovskiy, C. O. Ao, M. Borsche, A. von Engel, U. Foelsche, S. Heise, B. Iijima, Y.-H. Kuo, R. Kursinski, B. Pirscher, M. Ringer, C. Rocken, and T. Schmidt 2011: Estimates of the Uncertainty for using Global Positioning System Radio Occultation Data for Climate Monitoring: Inter-comparisons of matched profiles.

- Ho, S.-P., Y.-H., Kuo, Construction of a Consistent Microwave Sensor Temperature Record in the Lower Stratosphere Using Global Positioning System Radio Occultation Data and Microwave Sounding Measurements, *J. Geophys. Research*, 2011

-Mears C., J. Wang, S.-P. Ho, L. Zhang, and X. Zhou, Total Column Water Vapor, [In “States of the Climate in 2010]. *Bul. Amer. Meteor. Sci.*, 2011, in press (invited).

-Ho, S.-P., IPCC AR5 report (invited).

- Jerry Raj, Ching-Yuang Huang, S.-P. Ho, Jens Wickert, and Torsten Schmidt, Characteristics of Tropopause Height in Indian Monsoon Region Revealed by COSMIC GPS RO Data, *Geophys. Res. Lett.*, 2010 (submitted).

- Ho, S.-P., Y.-H. Kuo, X.-J. Zhou, P. Callaghan, 2011: The Use of the COSMIC/FORMOSAT-3 Global Positioning System Radio Occultation Data as Global Reference Observations in Orbit and Their Applications in Meteorology, *Horizons in Earth Science Research*, Vol. 5, B. Veress and J. Szigehty, Eds. NOVA Publishers, in press (invited).

- Ho, S.-P., Zhou X., Kuo Y.-H., Hunt D., Wang J.-H. Global Evaluation of Radiosonde Water Vapor Systematic Biases using GPS Radio Occultation from COSMIC and ECMWF Analysis. *Remote Sensing*. 2010; 2(5):1320-1330.

- Ho, S.-P., Ying-Hwa Kuo ,William Schreiner, Xijia Zhou, 2010: Using SI-traceable Global Positioning System Radio Occultation Measurements for Climate Monitoring [In “States of the Climate in 2009]. *Bul. Amer. Meteor. Sci.*, 91 (7), S36-S37 (invited).

- Mears C., J. Wang, S.-P. Ho, L. Zhang, and X. Zhou, 2010: Total Column Water Vapor, [In “States of the Climate in 2009]. *Bul. Amer. Meteor. Sci.*, 91 (7), S29-S31 (invited).

- Ho, S.-P., M. Goldberg, Y.-H. Kuo, C.-Z Zou, W. Schreiner, Calibration of Temperature in the Lower Stratosphere from Microwave Measurements using COSMIC Radio Occultation Data: Preliminary Results, *Terr. Atmos. Oceanic Sci.*, Vol. 20, doi: 10.3319/TAO.2007.12.06.01(F3C), 2009.

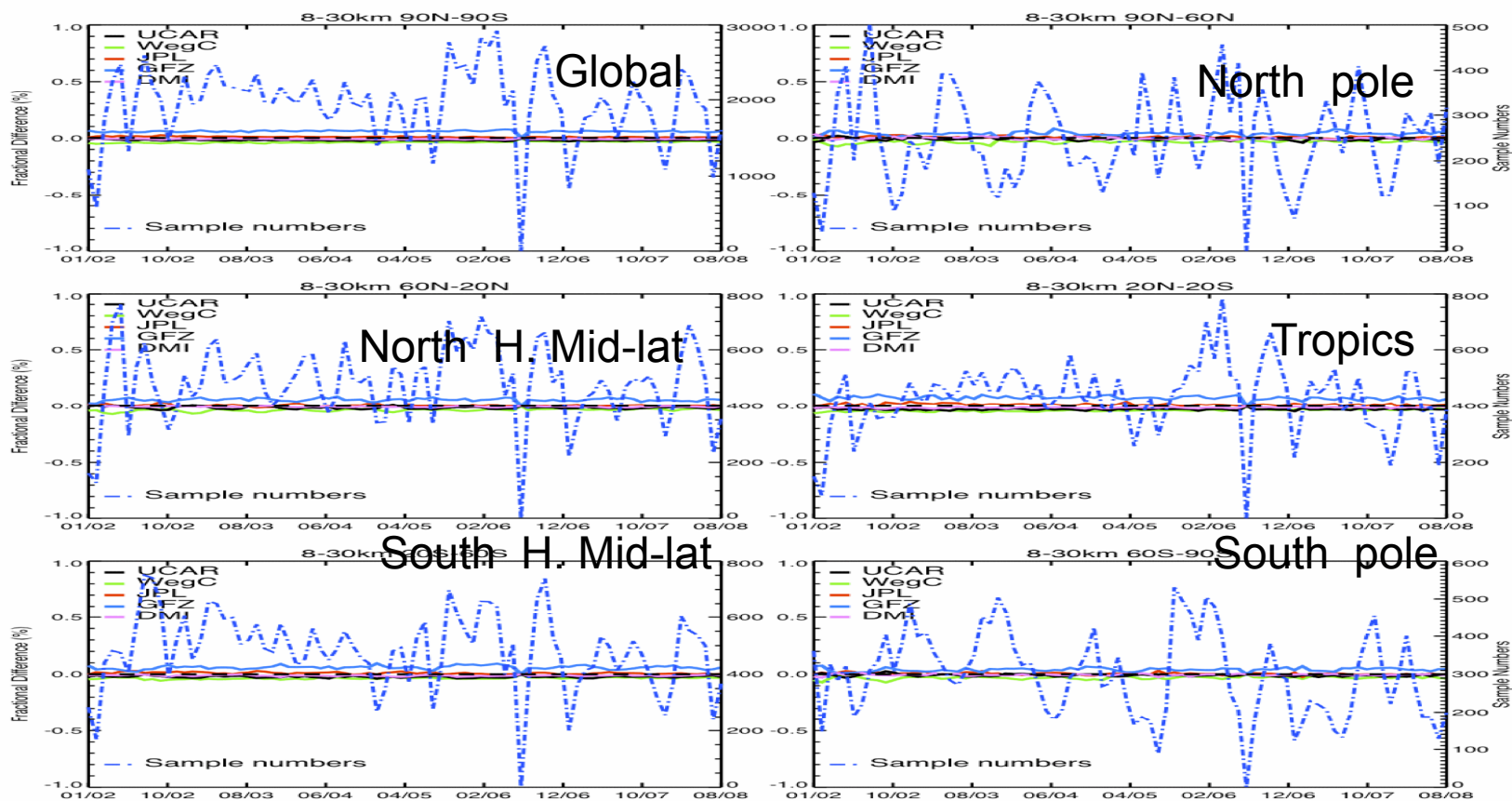
-Ho, S.-P., W. He, and Y.-H. Kuo, 2009, Construction of consistent temperature records in the lower stratosphere using Global Positioning System radio occultation data and microwave sounding measurements, in *New Horizons in Occultation Research*, edited by A. K. Steiner et al., pp. 207–217, Springer, Berlin, doi:10.1007/978-3-642-00321-9\_17.



# Key findings:

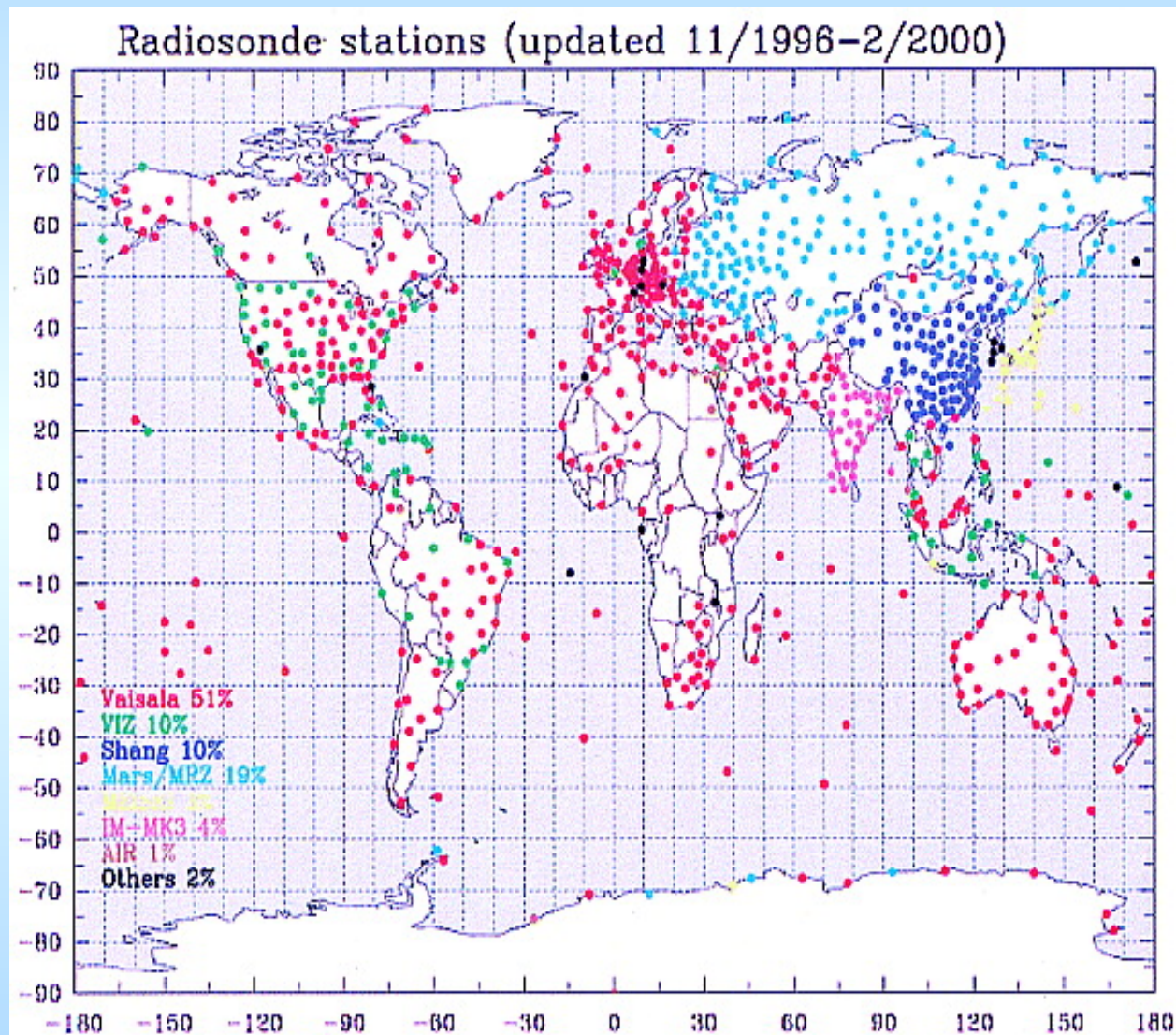
## a. Traceability of RO derived variables

Quantify the quality of RO data among different centers  
centers : reproducibility Ho, S.-P et al., JGR, 2010,2012,  
2013.

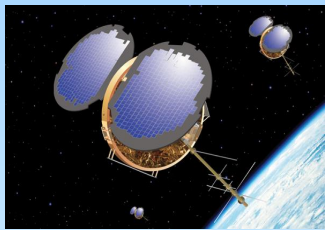




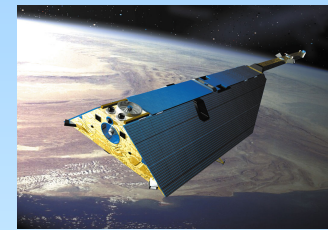
## b. Using RO data to Correct Diurnal variation of Radiosonde Temperature Anomalies



Region	Sonde Type	Matched Sample
Russia	AVK-MRZ	2000 (20%)
China	Shang	650 (6.1%)
USA	VIZ-B2	600 (5.9%)
Others	Vaisala	3140 (30%)



## b. Using RO data to Correct Diurnal variation of Radiosonde Temperature Anomalies



Solar absorptivity = 0.15

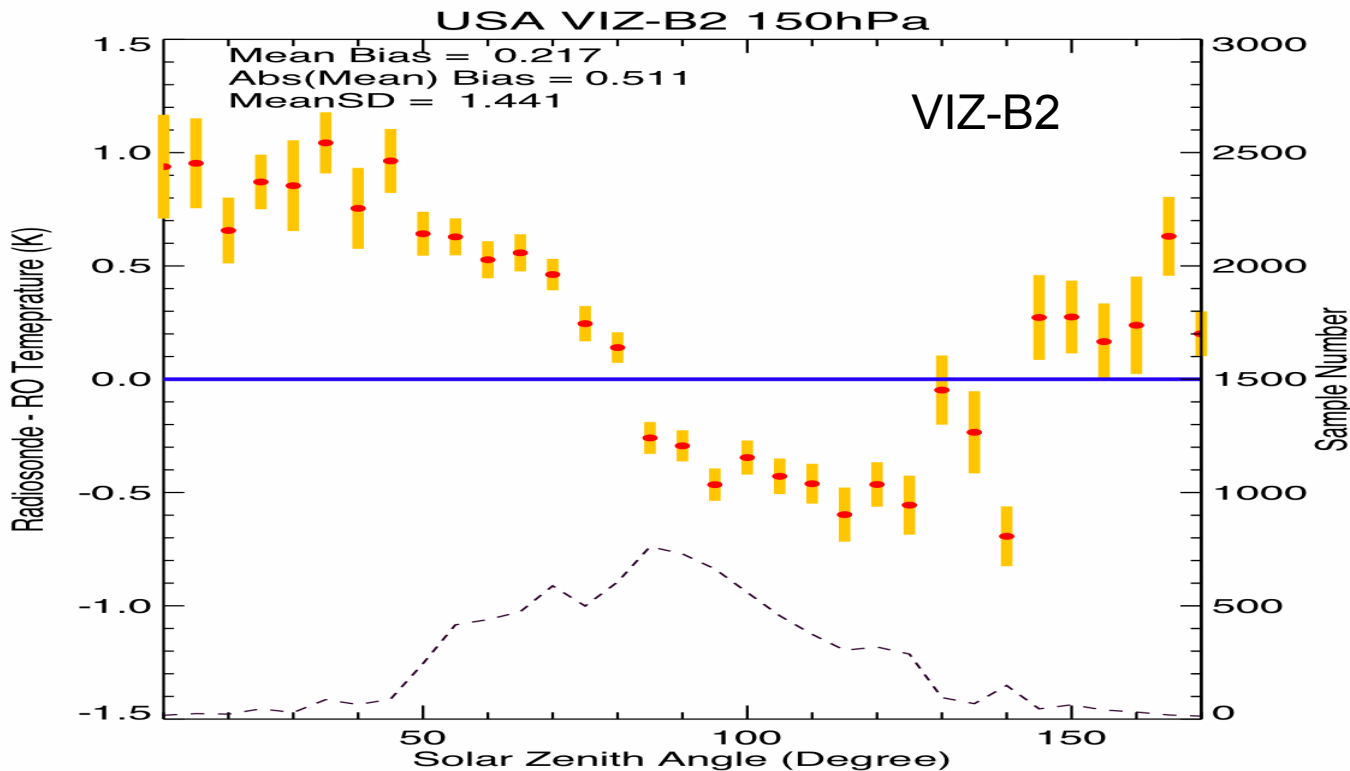
IR emissivity = 0.85

150 hPa

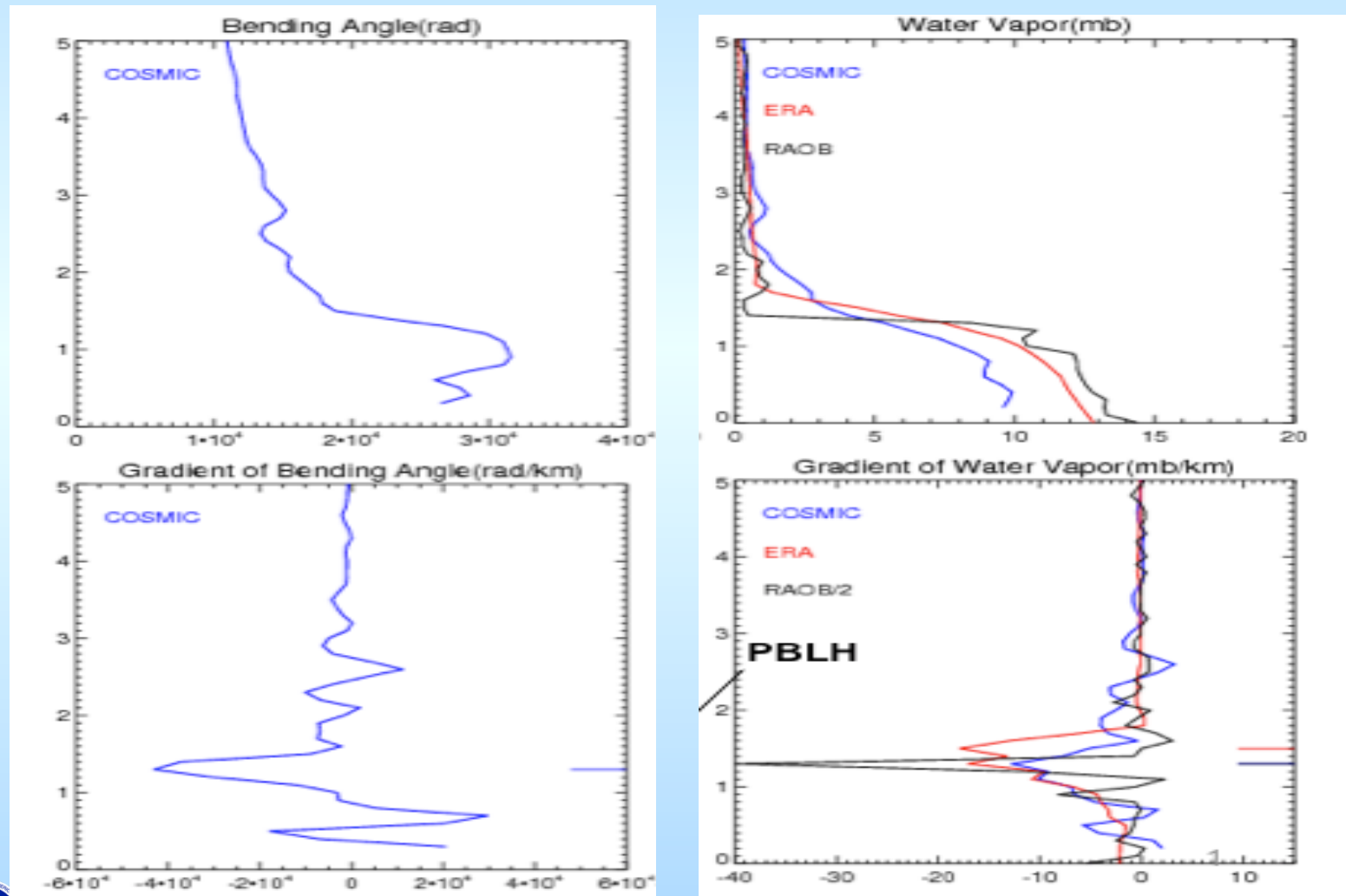
COSMIC from 2006 to 2009

CHAMP from 2001 to 2008

Radiosodne data DS351.0 from NCAR



## c. Detection of sharp inversion layer in the atmosphere



# 5. Schedule

- CDR status
  - is the delivered CDR up-to-date? if not, when will it be (to the extent possible)?
- a. Refining the SNO method for the data from 1978 to 2000**
- b. Linking data from 1978 to 2000 and from 2000 to 2012**
- c. Refining the algorithm to combining tropopause height derived from multiple RO missions from 2001 to 2013**



# 1-3 Year Planning Horizon

## New inputs:

**Forward processing : Microwave sounders from ATMS, AMSU-A from Metop-A/-B. GPS RO data from Metop-B, GRACE, TERRASAR-X etc in UCAR**

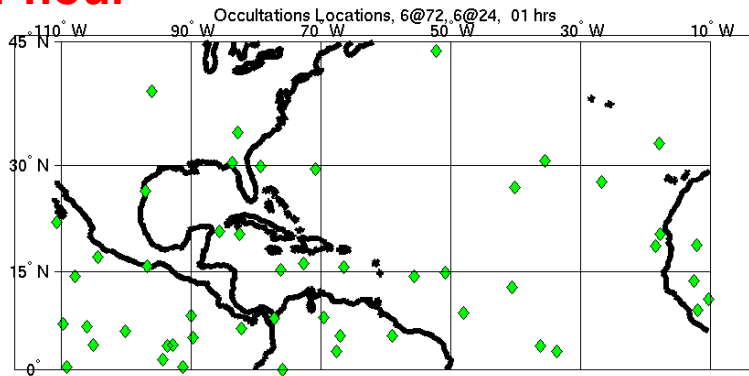
**More after 2016 during the COSMIC-2 Era (6000 profiles/day since 2016, 12000 profiles/day since 2018)**

**Backward processing : Re-processing MSU/AMSU before RO Era (before 2001)**

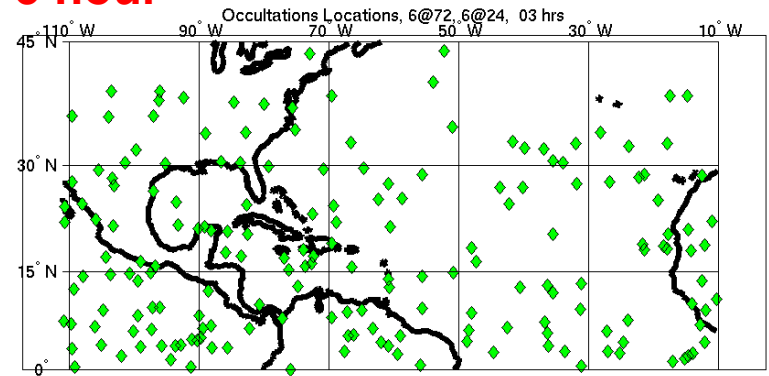
**Merging with in situ RAOB data before 1978**

# FORMOSAT-7/COSMIC-2 Soundings GPS and GLONASS

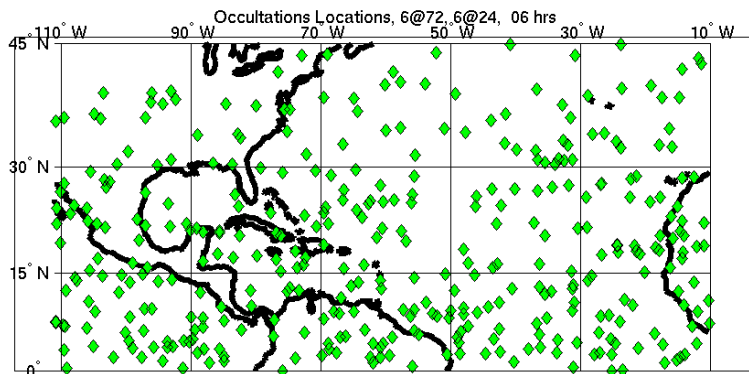
**1 hour**



**3 hour**



**6 hour**



**24 hour**

