COSMIC-2 Product Validation at NESDIS/STAR Using Global Radiosonde Observations

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> and NOAA STAR GNSS RO team Jan. 14, 2020

Motivation

Is the quality of COSMIC-2 data consistent or better than those of COSMIC-1 in terms of precision, long term stability, accuracy in the lower stratosphere, troposphere, particularly in the lower troposphere ?

High precision (<0.05K), No mission dependent bias (Ho et al., TAO, 2009; Ho et al., JGR, 2009; Anthes, 2007; **Ho et al., 2019, BAMS)**



Fig. 5. Statistical comparison of CHAMP and COSMIC RO-retrieved refractivities between 30S and 30N to ECMWF global analysis for 28 August-22 September 2006. Black and red lines show mean deviation and +/- standard deviation around the mean. Blue lines show the percentage of retrieved profiles that penetrated to a given altitude.

Outlines

Data: UCAR COSMIC-2 from 6 LEO satellites from 07/16/2019 - 08/15/2019, in situ RS41 and RS92 radiosonde data, and STAR processed C2 bending angle, temperature, and water vapor profiles.

1.Precision : Inter-comparison of C2 early orbit data

- 2.COSMIC-2/COSMIC vs. GFS-6 hour forecast 3.COSMIC-2/COSMIC vs. RAOB
- 4.Fractional dynamic bending angle observation error comparisons
- 5. Conclusions

1. Precision : COSMIC-1 and COSMIC-2

COSMIC2: 2019-07-16 to 2019-07-20, C2E1 and C2E4, in solid line COSMIC: 2006-04-22 to 2006-10-20, FM3 and FM4, in dashed line, number is normalized to COSMIC2



Bending angle fractional difference (%) Refractivity fractional difference (%) Temperature Difference (K)

2. COSMIC-2/COSMIC vs. GFS-6 hour forecast

COSMIC2: Oct 2019, in solid line COSMIC: Oct 2019, in dashed line, number is normalized to COSMIC2



RO – GFS Specific Humidity Difference (%)

RO – GFS Refractivity Fractional Difference (%)

Difference (K)

3. COSMIC-2/COSMIC vs. RAOB

COSMIC2: Oct 2019, in solid line COSMIC: Oct 2010-2019, in dashed line, number is normalized to COSMIC2



COSMIC-2 vs. RAOB Within 300 km and 2 hours Within 45 N and 45 S



Comparison with STAR Retrievals

STAR ROPP profiles after QC (removing ~ 20% of data)

UCAR profiles after QC (removing ~ 20% of data)



UCAR COSMIC2 N – RAOB N



Residual N_{UCAR} - N_{SIM}(RAOB): COSMIC2 2019.197 - 2019.239

STAR COSMIC2 N – ROAB N

Residual N_{ROPP} - N_{SIM}(RAOB): COSMIC2 2019.197 - 2019.239



UCAR COSMIC 2 W – RAOB W



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STAR COSMIC2 W – RAOB W



 $\Delta H = H_{RTR}(N=N_{ROPP}) - H_{RAOB}$: COSMIC2 2019.197 - 2019.239

4. Fractional DBAOE comparisons

Fractional DBAOE is defined as 100% x LSW/2 / bending angle

COSMIC2

Fractional DBAOE (%) in 2km sea level height, cosmic2 processed by UCAR, 07/16/2019 - 08/15/2019



cosmic, 2019 spring



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Fractional DBAOE comparisons

Fractional DBAOE (%)

Fractional DBAOE is defined as 100% x LSW/2 / bending angle

Fractional DBAOE (%)

MSL Altitude, (km)

30S-45S 30N-30S 45N-30N 30N-30S, setting, GPS, Oct 2019 45N-30N, setting, GPS, Oct 2019 30S-45S, setting, GPS, Oct 2019 cosmic2 cosmic2 cosmic2 cosmic cosmic cosmic MSL Altitude, (km) MSL Altitude, (km)

Mean Fractional DBAOE, Oct 2019

Fractional DBAOE (%)

5. Conclusions



NOAA/STAR in-house Expertise to support CWDP/COSMIC-2/Tasks

Non-local Bending Angle (Ray-tracing)

Data

Data Assimilation

Assimilation

Local Bending Angle (Forward Abel)

Local Refractivity

JCSDA and TMP project

As JCSDA partners, STAR and NCEP work together closely to perform impact assessment Multi-sensor Validation

Radiosonde (Dr. Xi Shao from CICS)

Microwave Sounders ATMS, AMSU-A (CICS)

Infrared Sounders CrIS, AIRS, IASI (Dr. Erin Lynch from CICS)

Retrievals (temperature, water vapor)

ECMWF model

Validari

Well established NOAA system NPROVS for sounding validation Integrated Cal/Val System (ICVS) for Monitoring

Operational monitoring

RO measurements

Parameters for all RO data levels

Statistics

Performance Monitoring

Long-term monitoring

(Mr. Xinjia Zhou GST

Dr. Yuxiang He GST

Dr. Ling Liu CICS)

Well established system for all NOAA satellites expanded to include RO; tested using KOMPSAT5, KOMPSAT5, COSMIC, Metop-A, -B, -C GRAS data data **NO Data Processing**

Time delay (LO-L1): Dr. Bin Zhang, Jun Dong from CICS and Yuxiang He from GST)

Excess phase

POD

ndependent Verification

Bending angle (L1- L2): Dr. Lok Adhikari (CICS)

Impact parameter

Refractivity

Geometric height

Temperature, water vapor, pressure: Dr. Stanislav Kireev (GST)

Tested & verified using ROPP (EUMETSAT) and KOMPSAT5, COSMIC, Metop-A, -B, -C GRAS data

Four major focus areas of Cal/Val work have been defined