Thermosphere model evaluation at low altitude with GOCE densities

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Introduction

- CIRA models are evaluated: NRLMSISE-00, JB2008 and DTM2013
- GOCE density data from 11/2009 – 11/2013 is used (270-170 km), Metric: mean, sigma, RMS and correlation of density ratio O/C
- Evaluate on long (years), medium (month) and short (day, hours) time scales

GOCE densities dawn profile (open), and DTM2013 (solid)

Number of obs. = 269
Mean / Std O/C = 0.914 / 0.072
R = 0.987
min = 0.743 / max = 1.028

GOCE (2009 – 2013):
- accelerometer
- ion propulsion
- GPS and SLR
- inclination: 96.5°
- Altitude: 270-170 km
- 10-s densities, precision 1-2%
Introduction

GOCE densities:

- **Low altitude**
- **Low-medium solar activity**
- **6-8am/pm local solar time**

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**Models: solar proxies:**
- **NRLMSISE-00:** F10.7
- **JB2008:** S, F10.7, M, Y
- **DTM2013:** F30

*Download F30 here: ftp://ftpsedr.cls.fr/pub/previsol/solarflux/final*
Density ratios O/C: NRLMSISE-00

All data mean O/C ratios: NRLMSISE-00

2010.0 2010.5 2011.0 2011.5 2012.0 2012.5 2013.0 2013.5 2014.0

Year

Mean and StD (of O/C time series): 1.05 / -  (All data)
Density ratios O/C: NRLMSISE-00

Mean and StD (of O/C time series): 1.05 / 0.051 (Per year)
Density ratios O/C: NRLMSISE-00

All + yearly + monthly mean O/C ratios: NRLMSISE-00

Mean and StD (of O/C time series): 1.05 / 0.067  (Per month)
Density ratios O/C: NRLMSISE-00

Mean and StD (of O/C time series): 1.05 / 0.098 (Per day)
Density ratios O/C: NRLMSISE-00

All...1/2 Rev mean O/C ratios: NRLMSISE-00  *(black= daily mean re-entry phase)*

Mean and StD (of O/C time series): 1.05 / 0.109  *(Per asc/desc arc)*
Density ratios O/C: JB2008

All….1/2 Rev mean O/C ratios: JB2008 (black=daily mean re-entry phase) (proxies June 2016)
Density ratios O/C: DTM2013

All…1/2 Rev mean O/C ratios: DTM2013 (black=daily mean re-entry phase)
StD of density ratio time series -vs- time scale

σ of annual time series: 0.014
of monthly time series: 0.037
of daily time series: 0.061
of ½ rev time series: 0.069 / 0.078 (dusk / dawn)
StD of daily-mean density ratios

GOCE densities dawn profile (open), and DTM2013 (solid)

- Number of obs. = 269
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(normalized) standard deviation of O/C ratios
NRLMSISE-00 (green), JB2008 (red), DTM2013 (blue)

- Mean = 10.0%
- Mean = 9.4%
- Mean = 8.5%

Latitudes

GOCE densities dawn profile (open), and DTM2013 (solid)

- Number of obs. = 269
- Mean / Std O/C = 0.914 / 0.072
- R = 0.967
- min = 0.743 / max = 1.028

StD of daily-mean density ratios

- Mean = 10.0%
- Mean = 9.4%
- Mean = 8.5%

Year

(2010.0 to 2014.0)

Number of obs. = 269
Mean / Std O/C = 0.914 / 0.072
R = 0.967
min = 0.743 / max = 1.028
Spectral analysis

Due to many, sometimes long, data gaps, the analysis was done on a 720-day interval from 12 February 2011 – 31 January 2013.

*Data gaps, short and few, are interpolated linearly.*

Power Spectrum daily-mean densities 12 Feb 2011 - 31 January 2013
GOCE=black / DTM2013=blue / JB08(March’17)=red / JB08(June’15)=pink / MSIS00=green
Spectral analysis

Observed density, NRLMSISE-00 and F10.7 (green), and DTM2013 and F30 (blue)
Spectral analysis

Errors are due to model and proxies; nrt data assimilation can correct both (HASDM)

Density data inferred from radar tracking on 60-70 objects are assimilated every 3 hours
Summary and Conclusions

✓ High resolution GOCE densities available
✓ CIRA models evaluated in the 270-170 km altitude range
✓ DTM2013 and JB2008 (*NB: proxies!*) most accurate and precise
✓ NRLMSISE-00 biased (*database and solar activity*)
✓ Models biased for lowest activity in 2009-10, most NRLMSISE-00
✓ Standard deviation of CIRA models at the 2-10% level (1-\(\sigma\))
✓ High correlation, most solar variations reproduced
✓ Representative results for all local times (using CHAMP, not shown)

• *Model errors on time scales of weeks-months: proxies & database*
• *Model error is not white (see density ratios)*