

Using Data Assimilation to Understand the Systematic Errors of CHAMP Accelerometer-Derived Neutral Mass Density Data

Kodikara, Timothy; FernandezGomez, Isabel ; Forootan, Ehsan; Tobiska, W. Kent ; Borries, Claudia

DOI (link to publication from Publisher):
[10.1002/essoar.10509636.2](https://doi.org/10.1002/essoar.10509636.2)

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Kodikara, T., FernandezGomez, I., Forootan, E., Tobiska, W. K., & Borries, C. (2021). *Using Data Assimilation to Understand the Systematic Errors of CHAMP Accelerometer-Derived Neutral Mass Density Data*. Abstract from AGU 2021 Fall Meeting, New Orleans, United States. <https://doi.org/10.1002/essoar.10509636.2>

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Using Data Assimilation to Understand the Systematic Errors of CHAMP Accelerometer-Derived Neutral Mass Density Data

Timothy Kodikara¹, Isabel Fernandez-Gomez¹, Ehsan Forootan², W. Kent Tobiska³, and Claudia Borries¹

1. German Aerospace Center (DLR), Germany

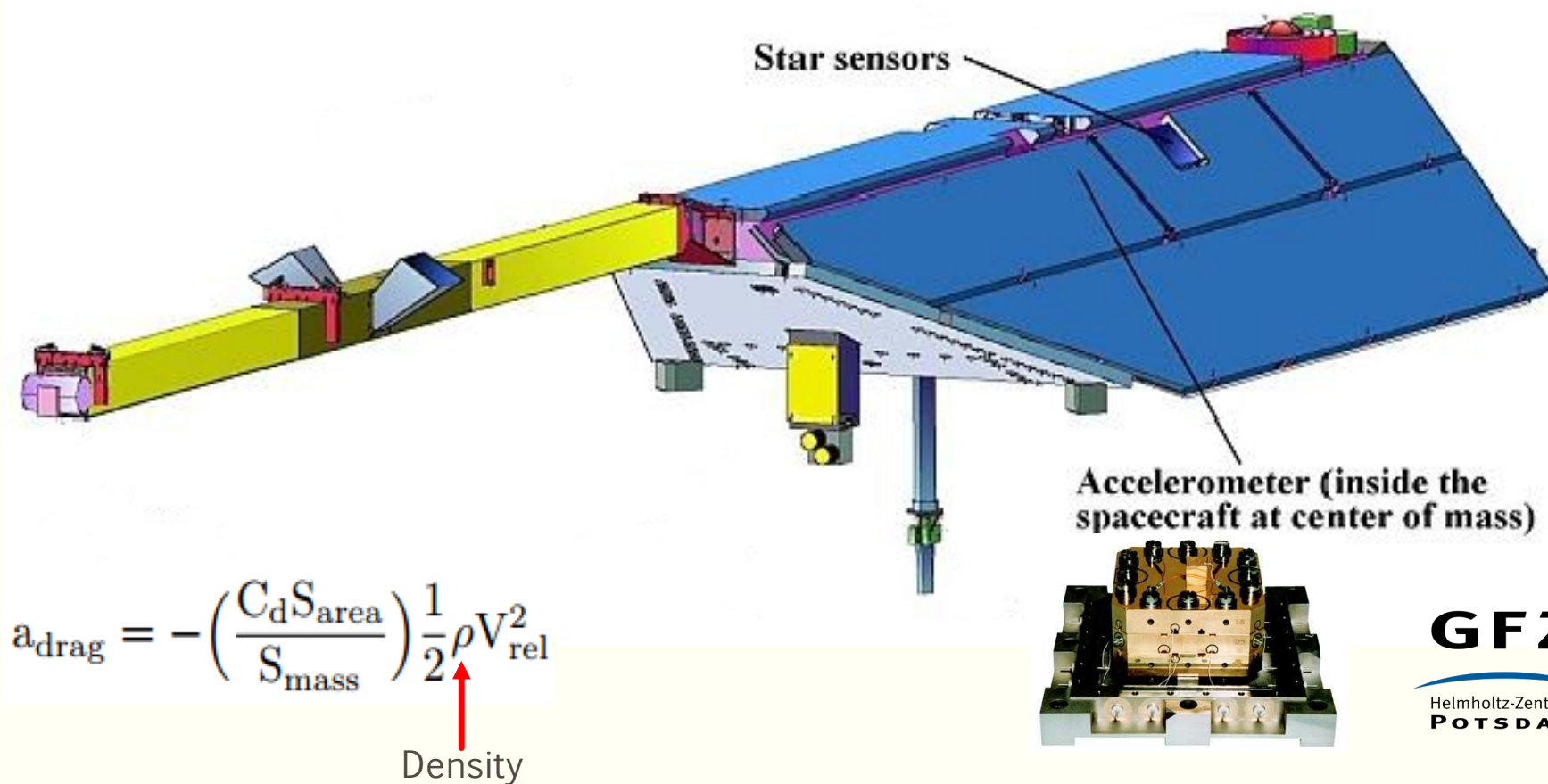
2. Aalborg University, Denmark

3. Space Environment Technologies, USA

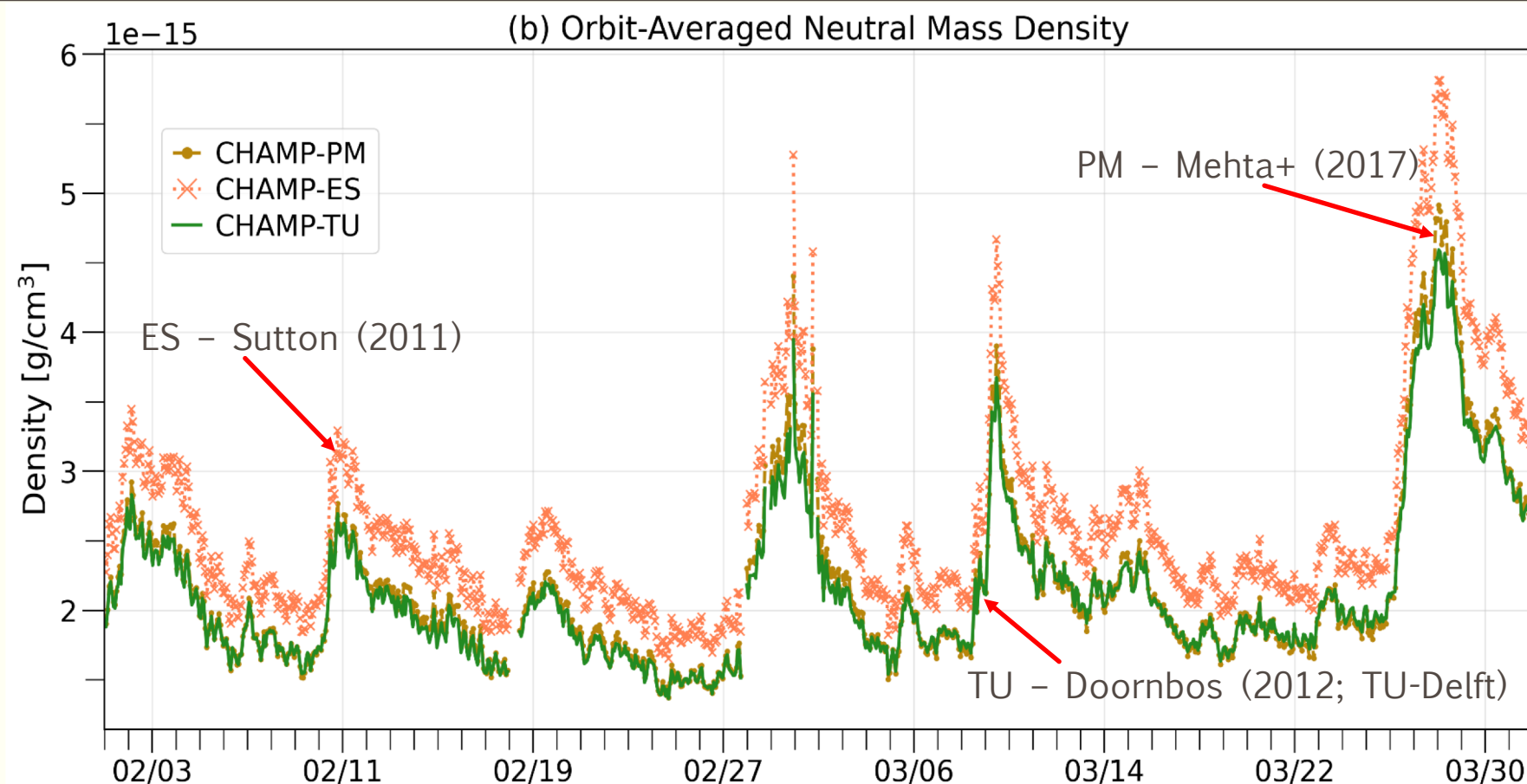
timothy.kodikara@dlr.de



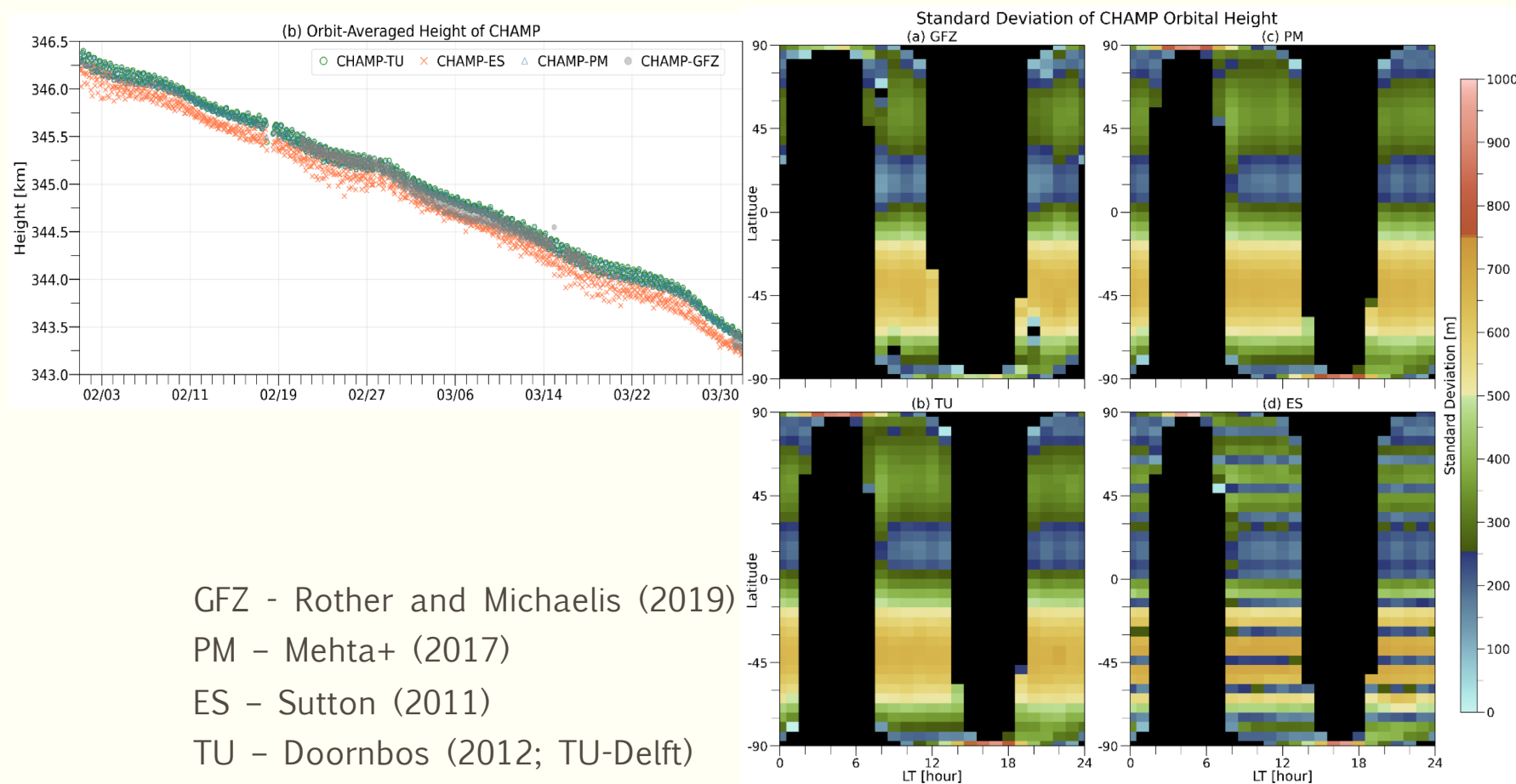
Neutral mass density can be derived from accelerometer measurements onboard CHAMP



The uncertainties of accelerometer-derived NMD are not fully understood

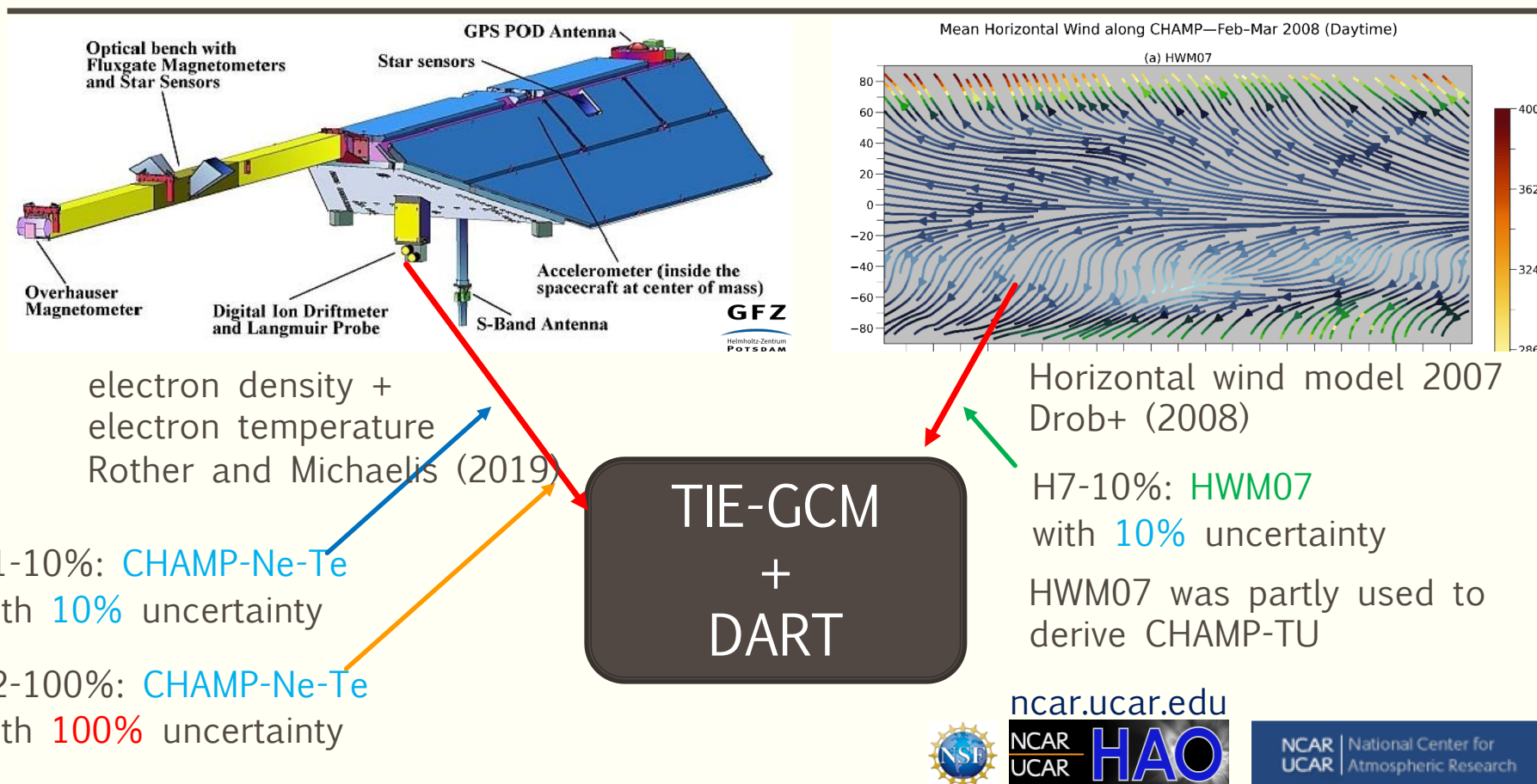


Some discrepancies exist in the published CHAMP height

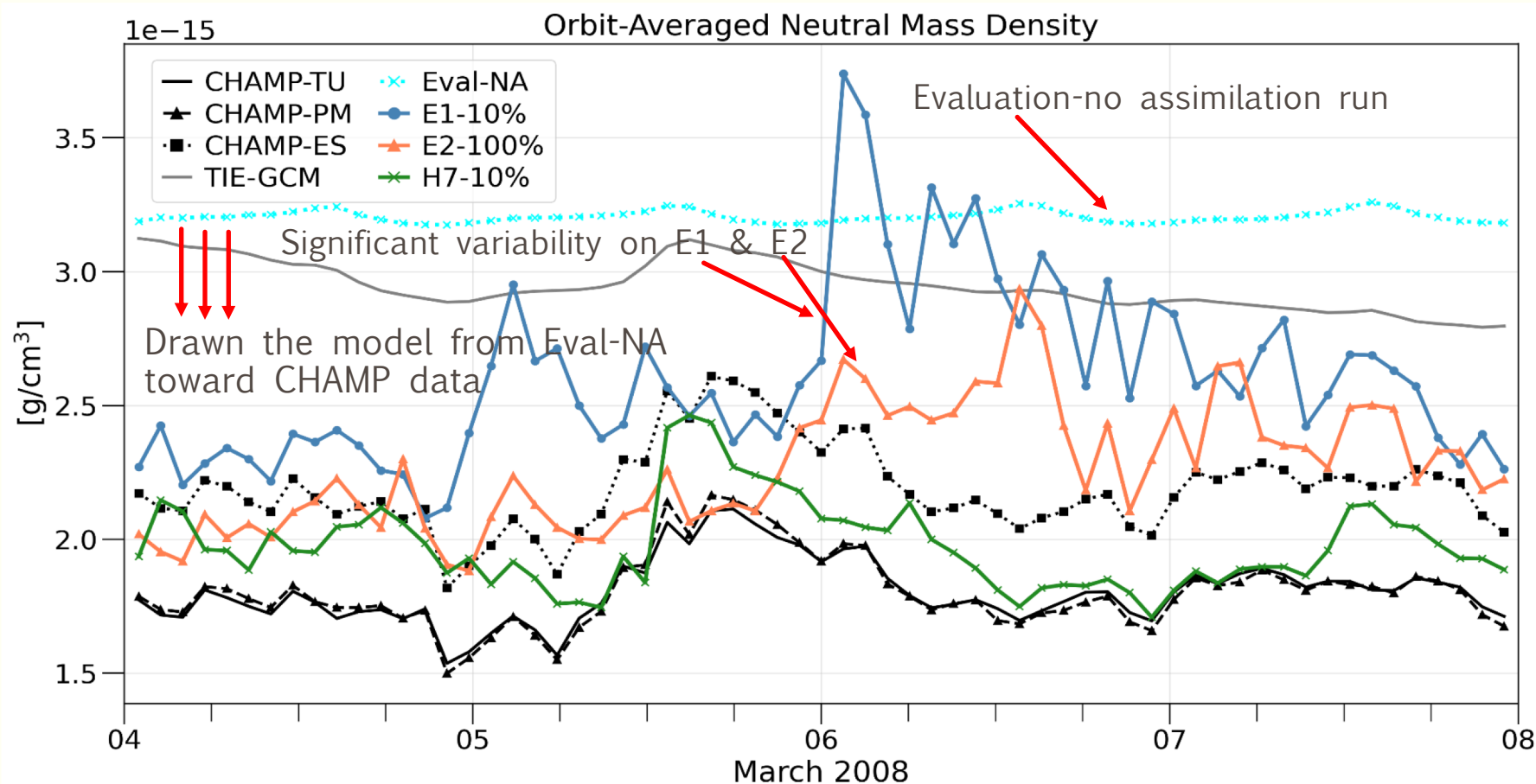


GFZ - Rother and Michaelis (2019)
 PM - Mehta+ (2017)
 ES - Sutton (2011)
 TU - Doornbos (2012; TU-Delft)

Assimilate observations along CHAMP to understand the impact on NMD



Assimilation of HWMo7 neutral winds greatly improves TIE-GCM's agreement with CHAMP neutral mass density



Estimating the Error Variance using the Grubbs' method

Grubbs (1948) "On Estimating Precision of Measuring Instruments and Product Variability", Journal of the American Statistical Association

Four instruments A, B, C, D measuring the same physical qty

$$A = T + E_A$$

$$B = T + E_B$$

$$C = T + E_C$$

$$D = T + E_D$$

$$\text{Var}(A - B) = \frac{1}{n} \sum_{i=1}^n (A_i - B_i)^2 - \langle A - B \rangle^2,$$

Error variance can be estimated independent of true value T

$$\sigma(E_A) = \sqrt{\text{Var}(E_A)} = \left\{ \frac{1}{3} \left(\text{Var}(A - B) + \text{Var}(A - C) + \text{Var}(A - D) \right) - \frac{1}{6} \left(\text{Var}(B - C) + \text{Var}(B - D) + \text{Var}(C - D) \right) \right\}^{\frac{1}{2}}.$$

Estimating the Error Variance using the Grubbs' method

Grubbs (1948) "On Estimatin
of the American Statistical Asso

Four instruments A, B, C, D
qty

$$A = T + E_A$$

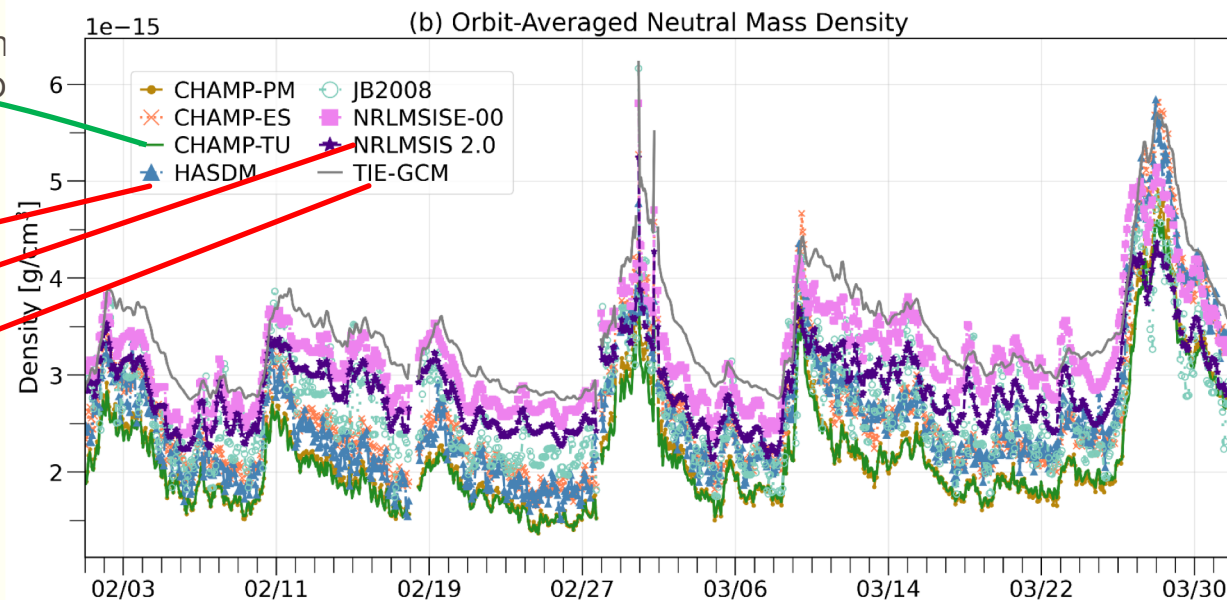
$$B = T + E_B$$

$$C = T + E_C$$

$$D = T + E_D$$

Error variance can be estimated independent of true value T

$$\sigma(E_A) = \sqrt{\text{Var}(E_A)} = \left\{ \frac{1}{3} \left(\text{Var}(A - B) + \text{Var}(A - C) + \text{Var}(A - D) \right) - \frac{1}{6} \left(\text{Var}(B - C) + \text{Var}(B - D) + \text{Var}(C - D) \right) \right\}^{\frac{1}{2}}.$$



Grubbs' method provide reliable estimates of the error

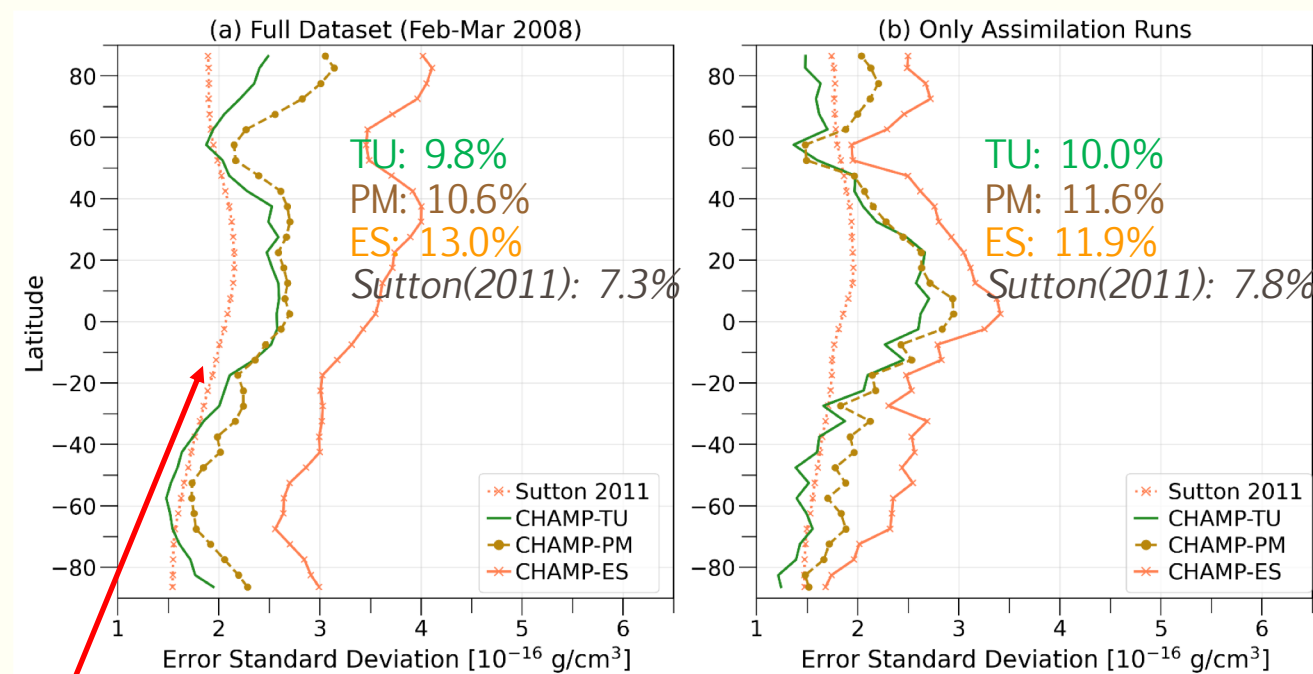
(b) uses only assim runs to estimate error (E1, E2, H7 as B, C, D instruments)

General agreement with previous estimates:

Bruinsma+(2004): 10-15%

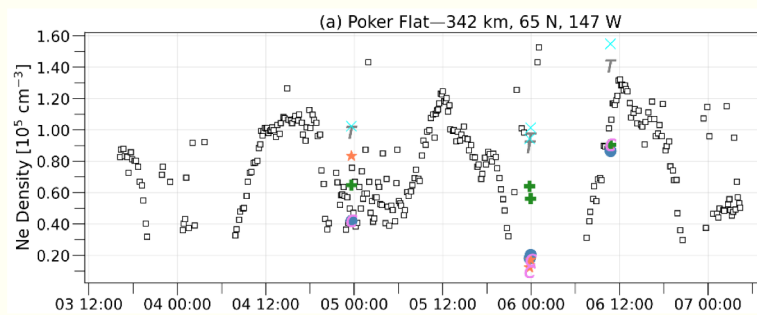
Sutton+(2007): 6-15.6%

Reveals latitudinal characteristics of error

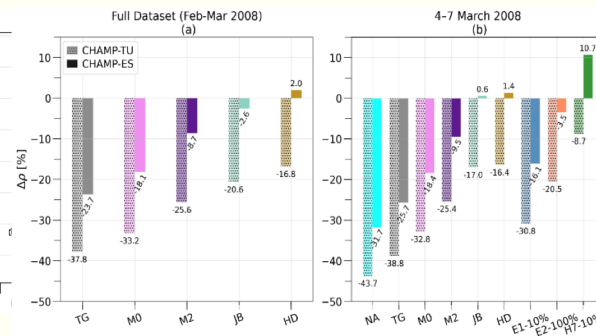


Error estimated by Sutton (2011) for CHAMP-ES data set

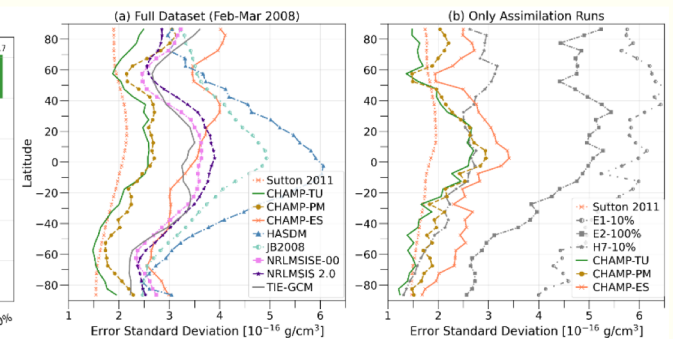
Validation with ISR data



Model Performance



Error Estimates



Using Data Assimilation to Understand the Systematic Errors of CHAMP Accelerometer-Derived Neutral Mass Density Data

Timothy Kodikara¹, Isabel Fernandez-Gomez¹, Ehsan Forootan², W. Kent Tobiska³, and Claudia Borries¹

1. German Aerospace Center (DLR), Germany

2. Aalborg University, Denmark

3. Space Environment Technologies, USA

timothy.kodikara@dlr.de

