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

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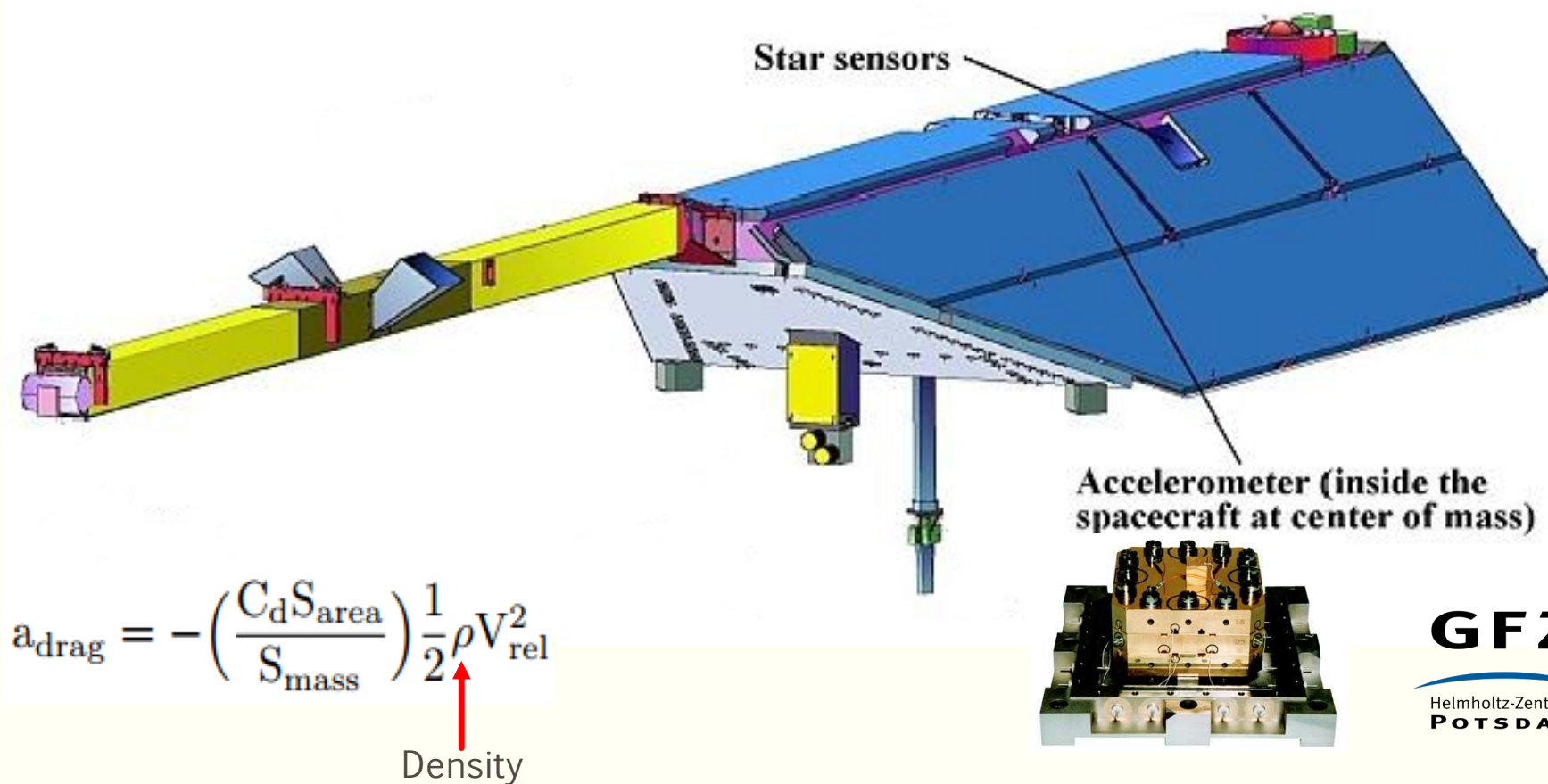
2. Aalborg University, Denmark

3. Space Environment Technologies, USA

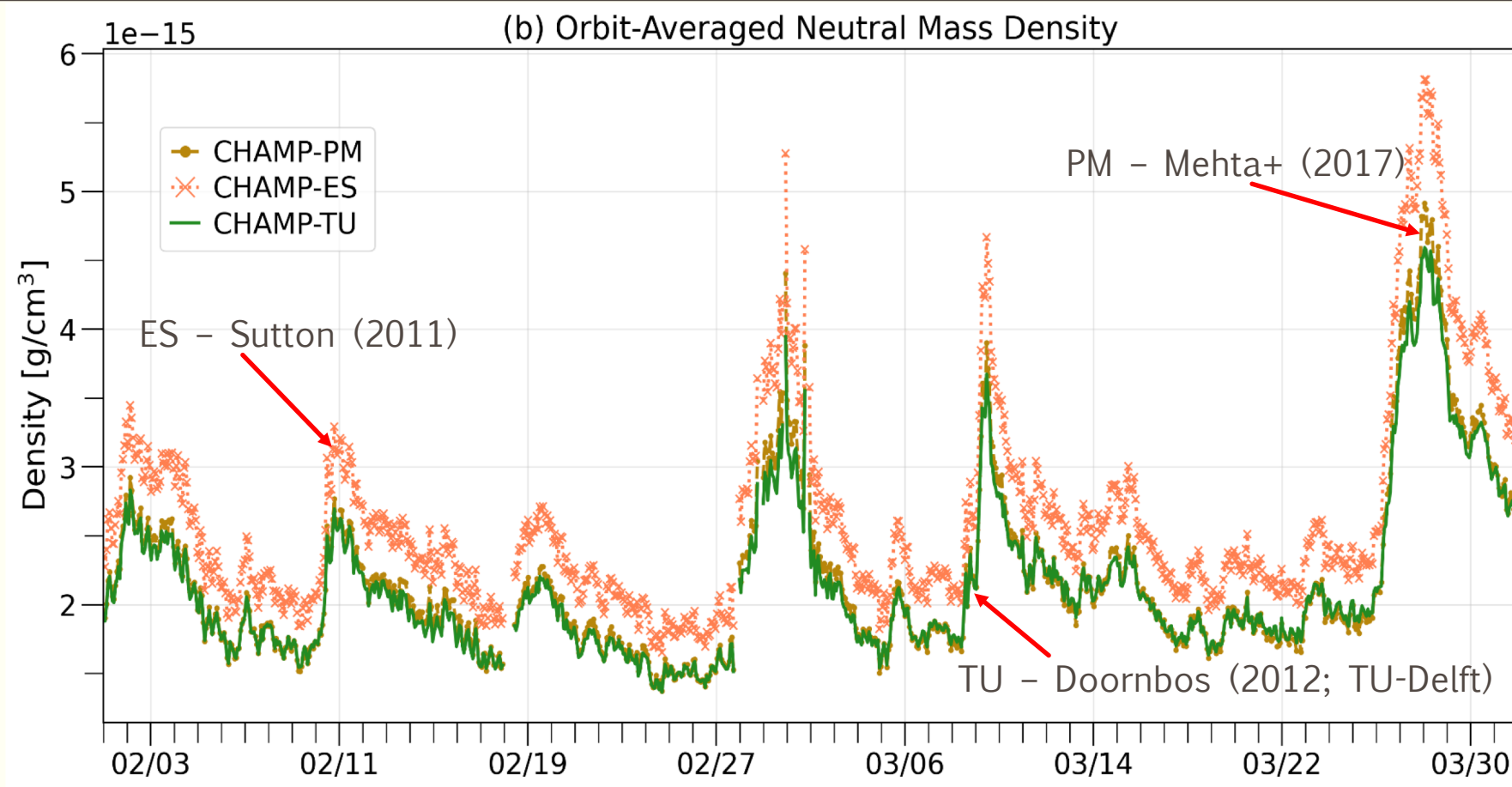
timothy.kodikara@dlr.de



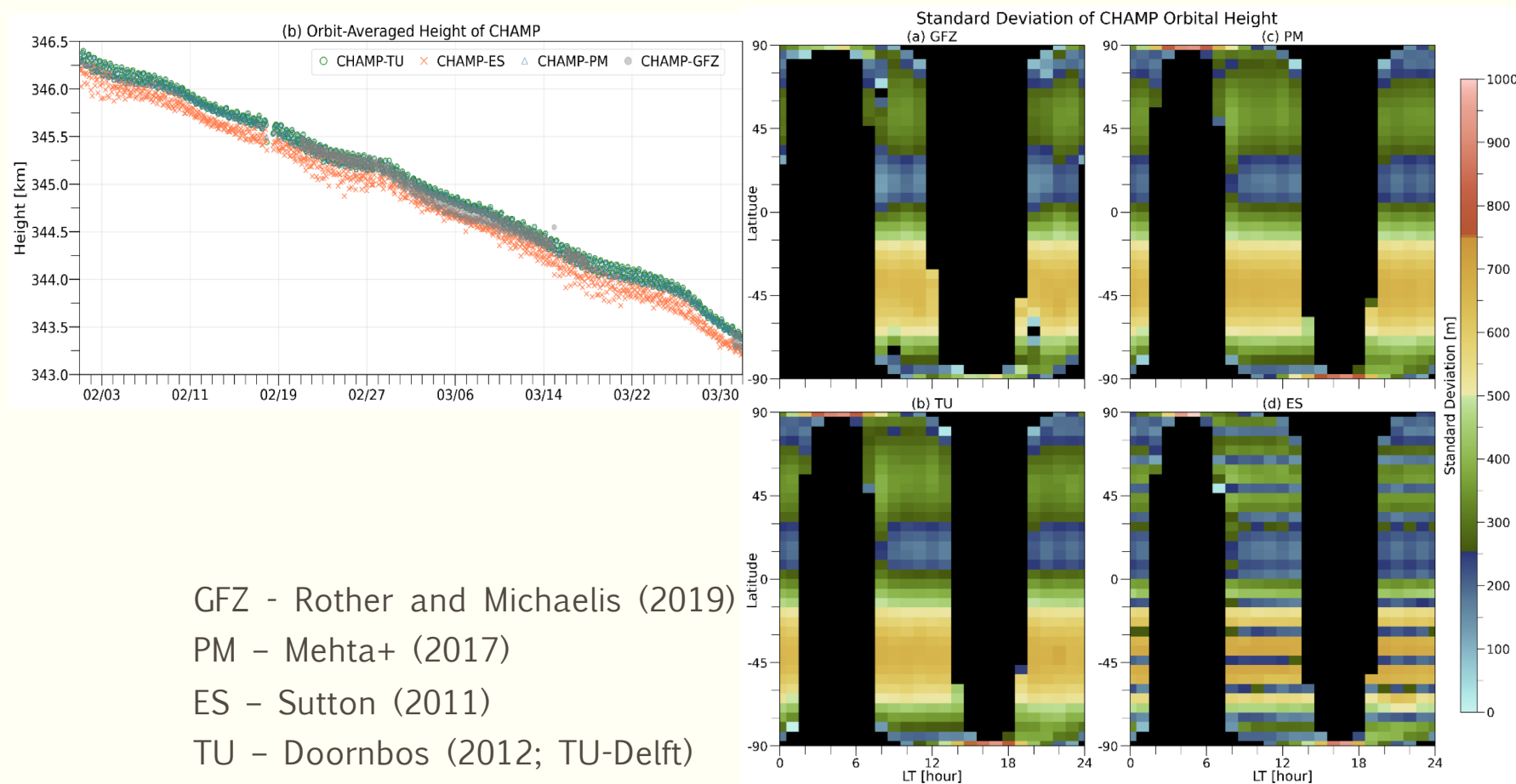
Neutral mass density can be derived from accelerometer measurements onboard CHAMP



The uncertainties of accelerometer-derived NMD are not fully understood



Some discrepancies exist in the published CHAMP height



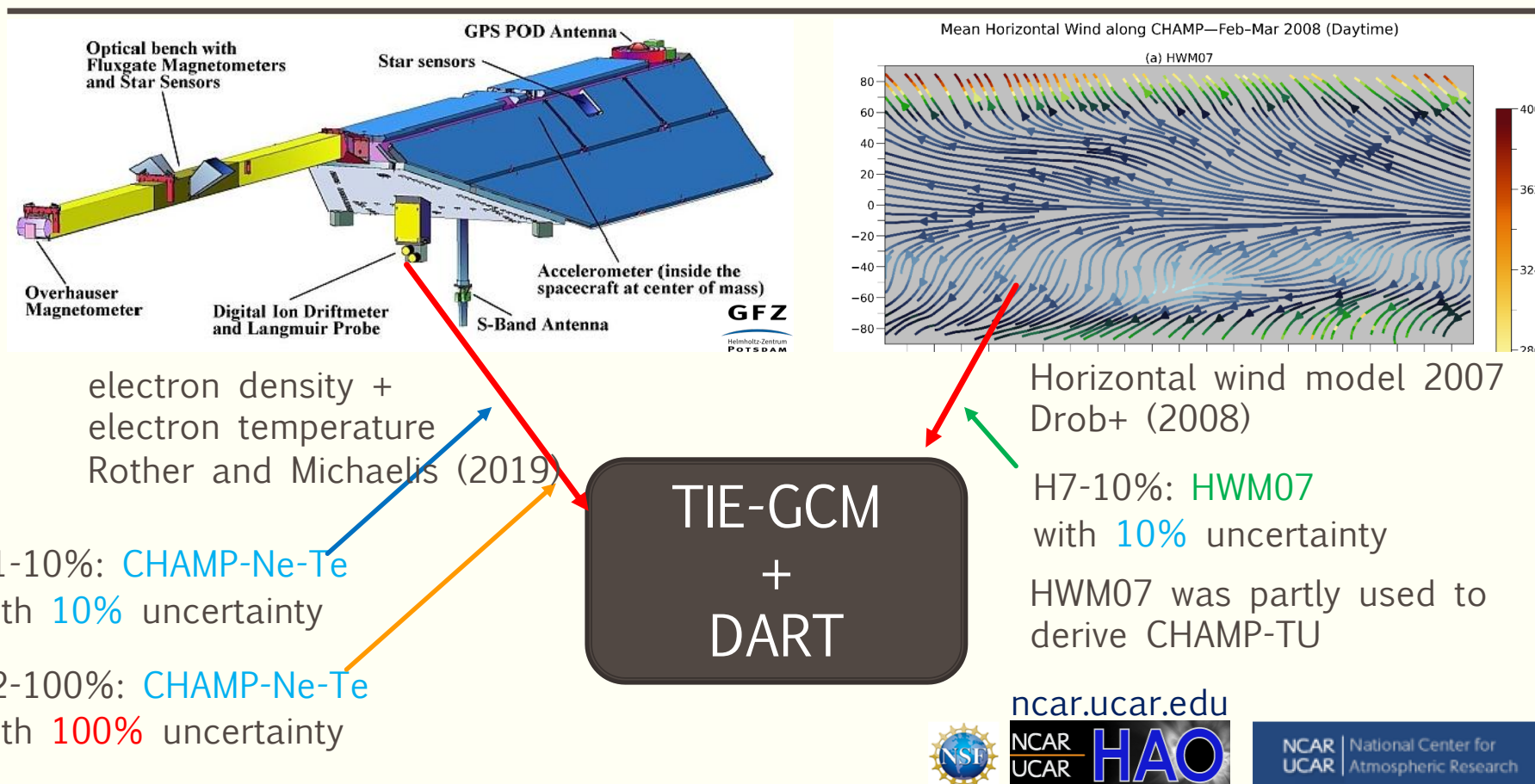
GFZ - Rother and Michaelis (2019)

PM - Mehta+ (2017)

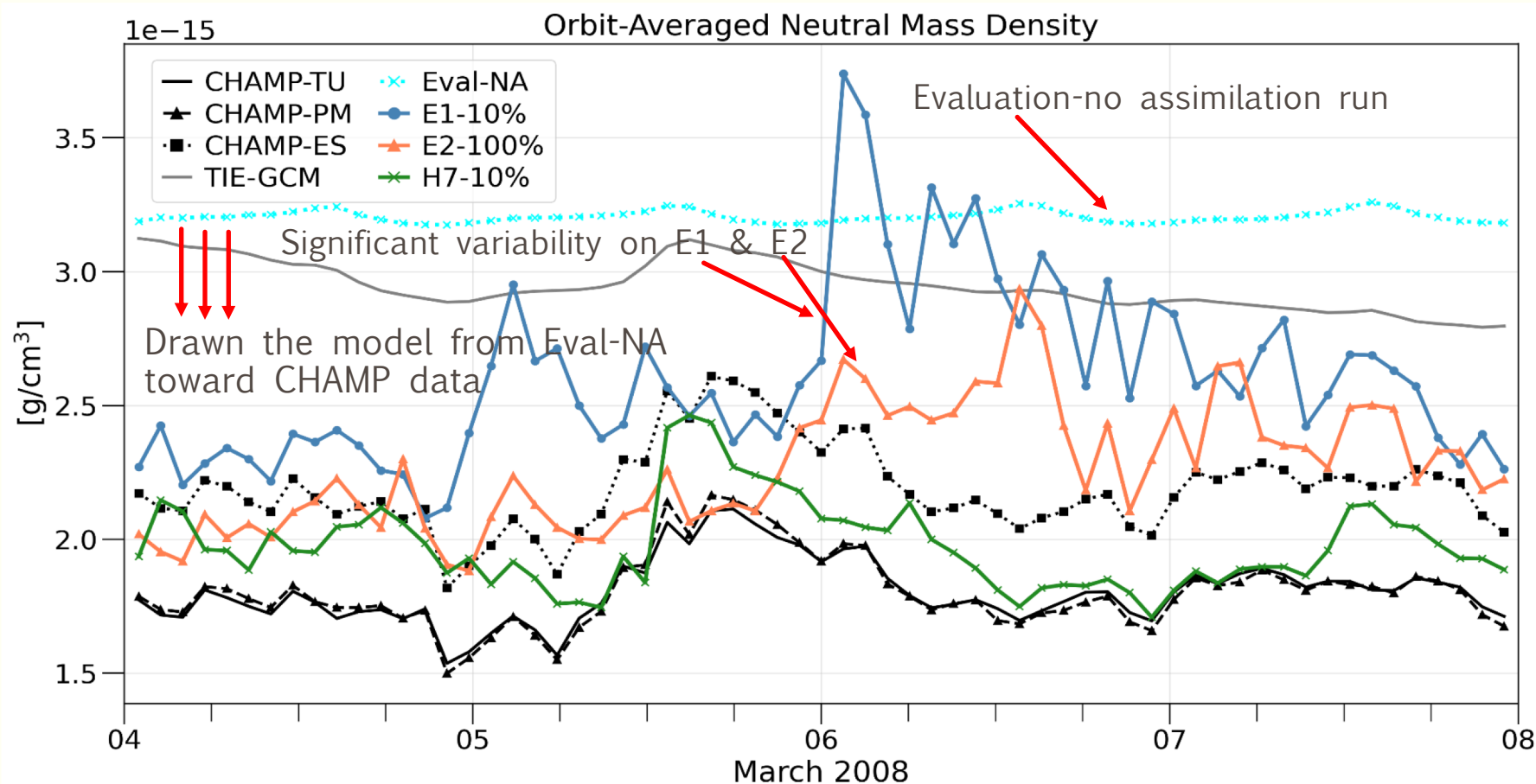
ES - Sutton (2011)

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
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Four instruments A, B, C, D
qty

$$A = T + E_A$$

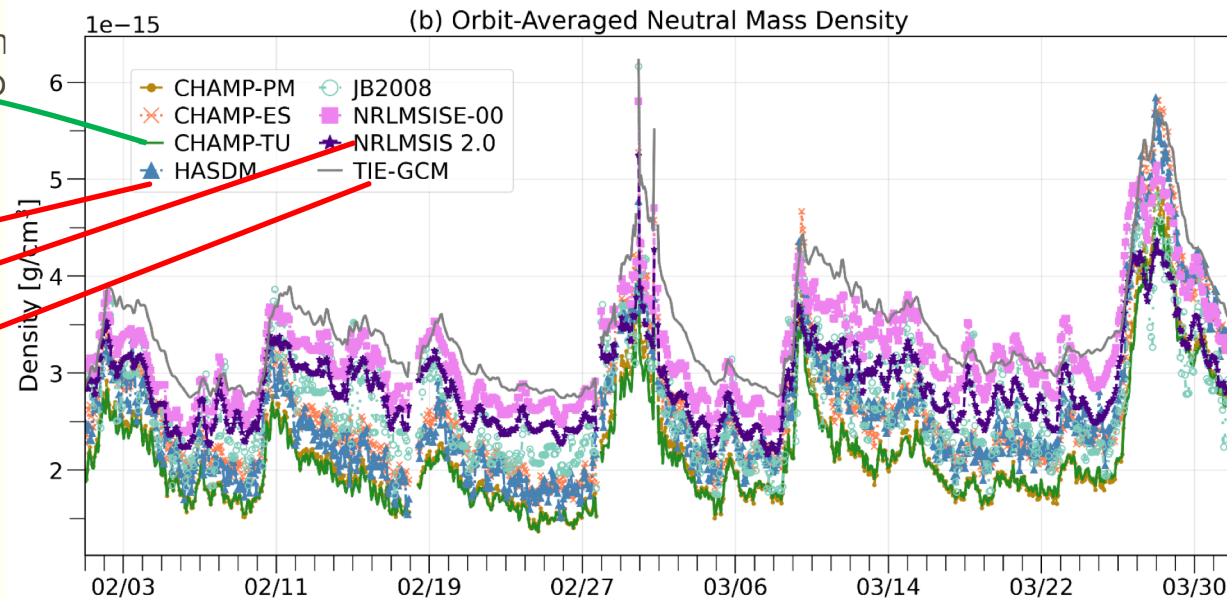
$$B = T + E_B$$

$$C = T + E_C$$

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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

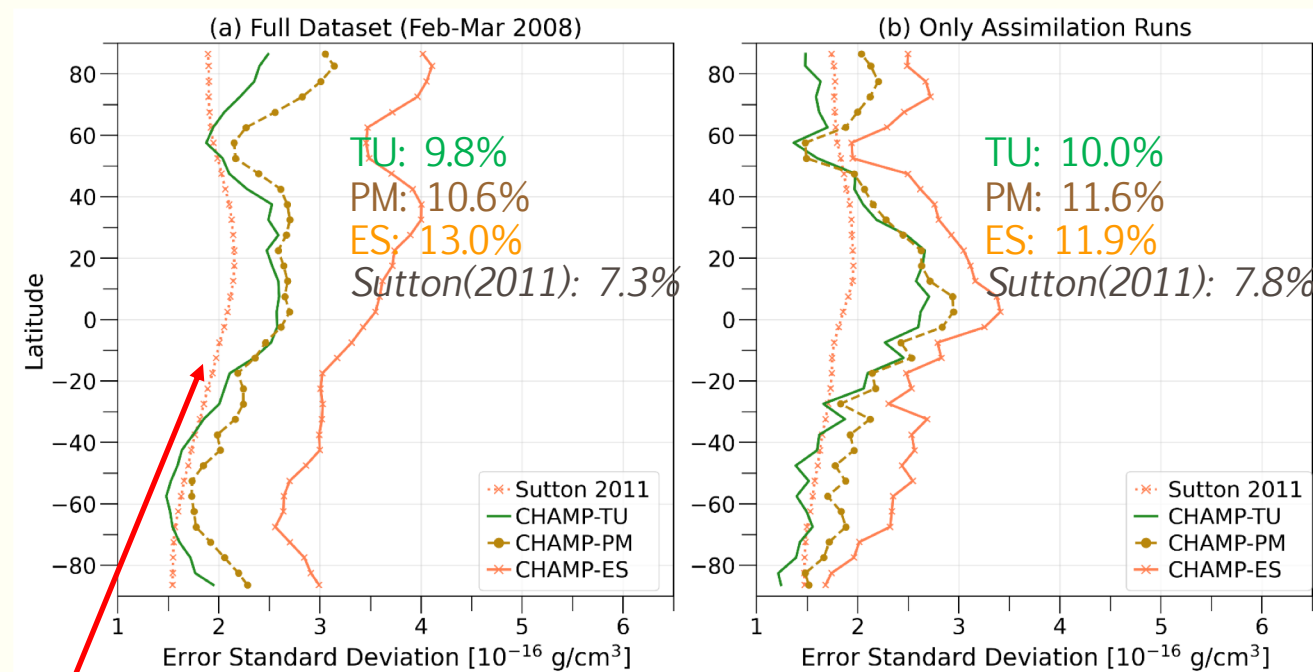
(b) uses only assim runs to estimate error (E1, E2, H7 as B, C, D instruments)

General agreement with previous estimates:

Bruinsma+(2004): 10-15%

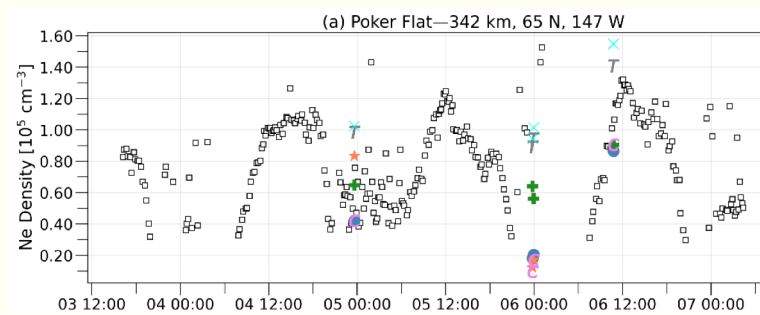
Sutton+(2007): 6-15.6%

Reveals latitudinal characteristics of error

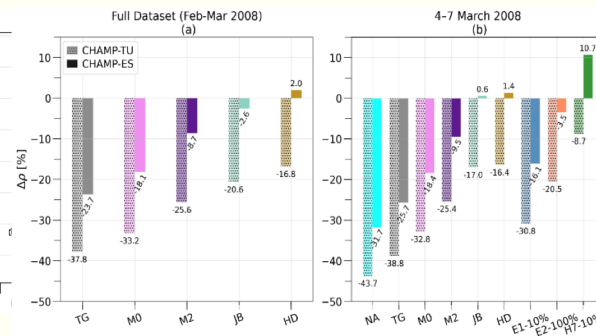


Error estimated by Sutton (2011) for CHAMP-ES data set

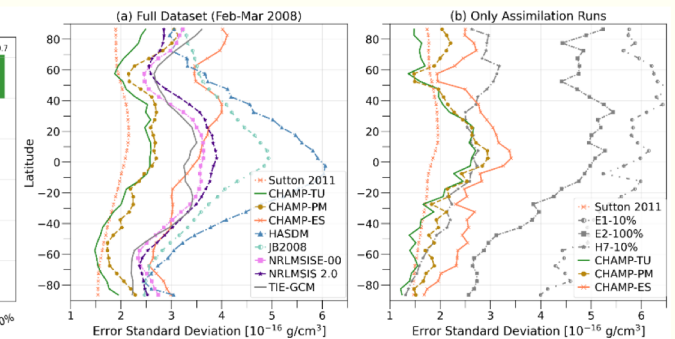
Validation with ISR data



Model Performance



Error Estimates



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