Comparison of thermospheric data assimilation with a drag temperature model for operational nowcasting and forecasting

Sophie A. Murray[1], E. M. Henley[1], D. R. Jackson[1], S. L. Bruinsma[2]
[1]Met Office, UK [2]CNES, France

1. Abstract

A thermospheric data assimilation (DA) procedure has been developed [1] using a general circulation model (TIEGCM) with satellite density measurements, as part of EU FP7 ATMOP [WP5]. Results were compared with the output of a semi-empirical drag temperature model (DTM). Independent observations from periods at solar minimum and maximum were used to compare analyses and forecasts from the two approaches. An mean improvement of ~10% was found, with DTM performing better at solar min and both models less accurate at solar max. With further improvements, the use of GCMs in operational forecasting (in addition to empirical models currently used) is plausible. Future work will allow near-real time assimilation of thermospheric data into TIEGCM for forecasting.

2. Models and Observations

- DTM-2012 [2] :
  - F10.7 solar and Kp auroral indices used as inputs; DA of satellite observations.
  - Resulting parameter at a specific latitude, longitude, and altitude between 200-1000km, and up to 1° resolution (see *Fig. 1a*).
- TIEGCM [3] :
  - F10.7 and Kp inputs using Heelis convection pattern [4]; DA procedure [1].
  - 3D model atmosphere from ~90-500km, and 5° resolution (see *Fig. 1b*).

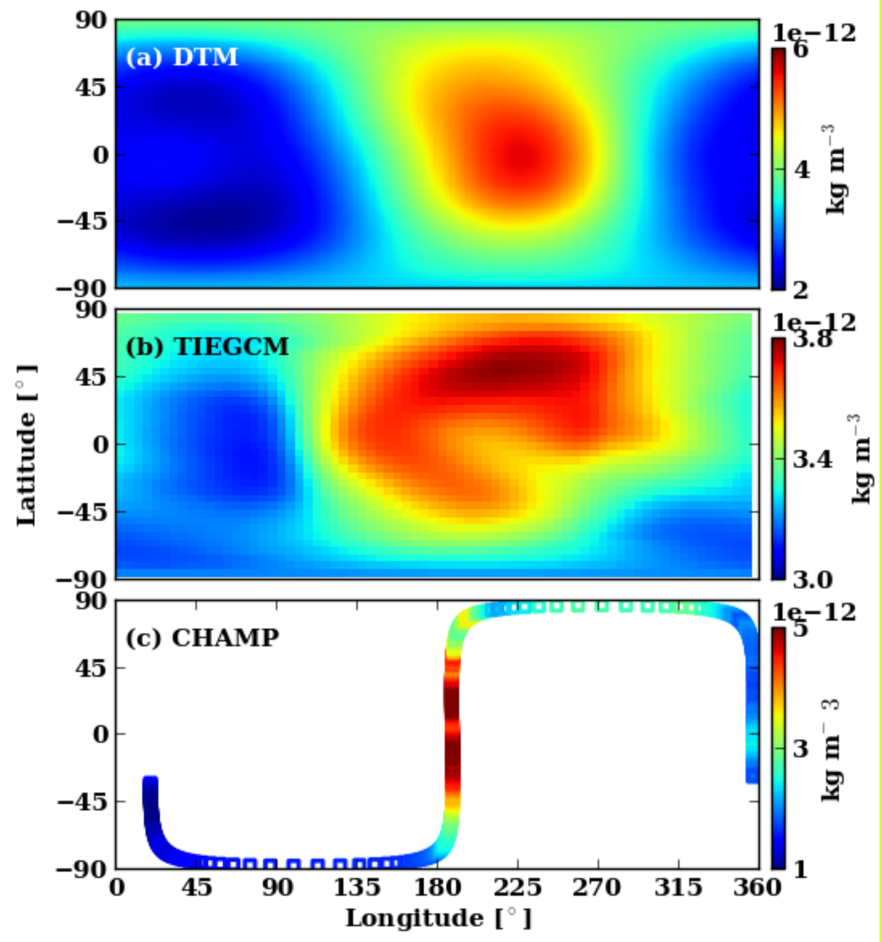

Figure 1: *a) DTM and b) TIEGCM densities on 2009 March 01 00:00UT; c) CHAMP densities between 2009 March 01 00:00 UT – 01:30 UT.*

- Neutral density observations inferred from CHAMP accelerometer (see *Fig. 1c*). CHAMP orbitted at ~400km in 2003 and ~330km in 2009.
- The new DA scheme was run with TIEGCM using observed indices as well as new F10.7 forecast proxies developed in WP2 of ATMOP [5].

3. Solar Minimum

- March 2009 was chosen for analysis. *Fig. 2* shows resulting densities at the latitude, longitude, and height of CHAMP (TIEGCM values have been interpolated).

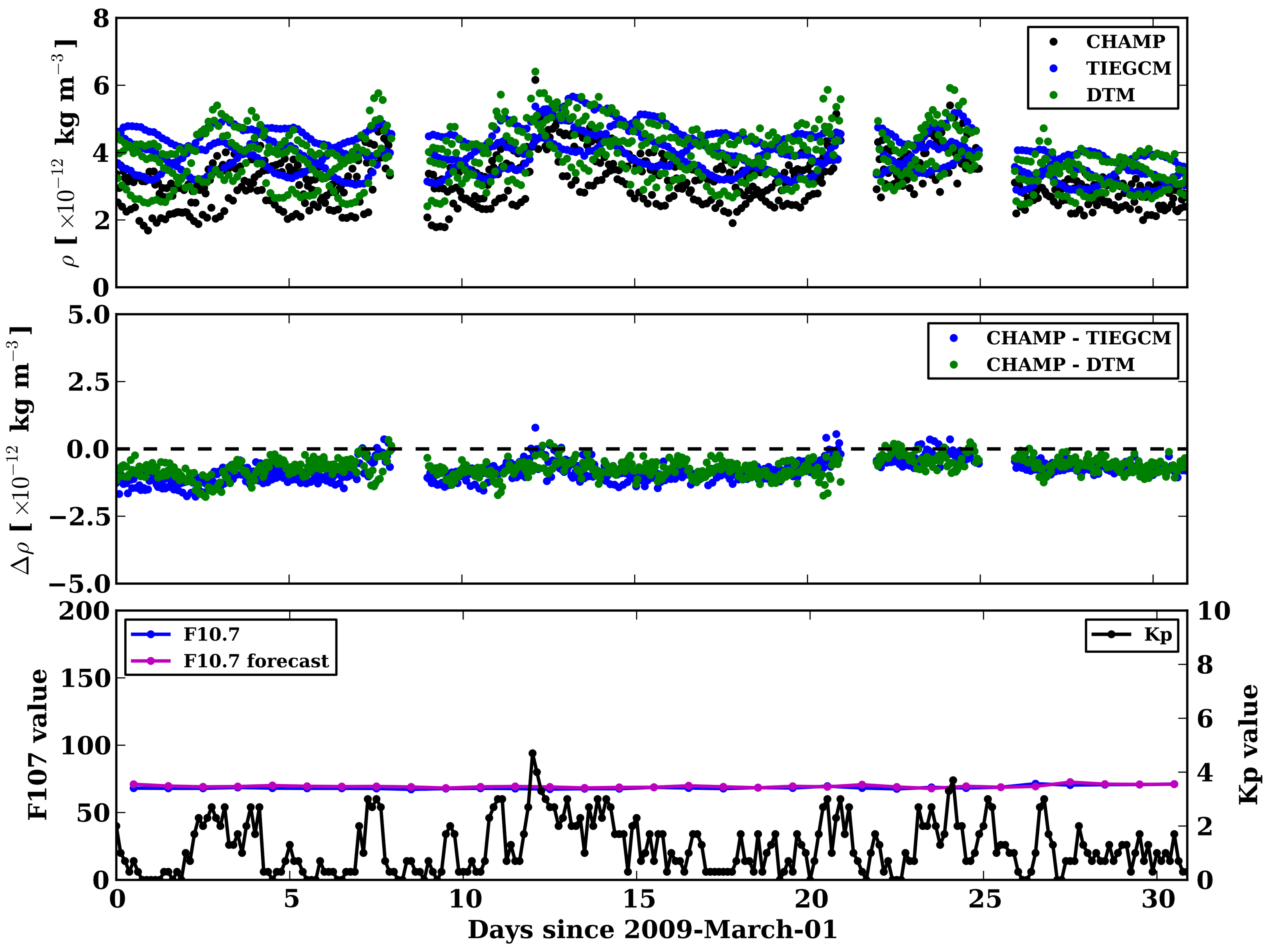

Figure 2: *Top: Hourly-averaged CHAMP, TIEGCM, and DTM densities for March 2009. Middle: Density difference between CHAMP and the two models. Bottom: Actual F10.7, forecasted F10.7, and Kp values (used as inputs to the models).*

- DTM performs best at solar min, however TIEGCM also agrees well, both having a small number of outliers.
- Using forecast proxies (not shown), results show a mean change of +2.3% for ρ_{TIEGCM}, +0.3% for ρ_{DTM}, and +1.4% for F10.7 values.

4. Solar Maximum

- March 2003 was chosen for analysis. *Fig. 3* shows resulting densities at the latitude, longitude, and height of CHAMP.

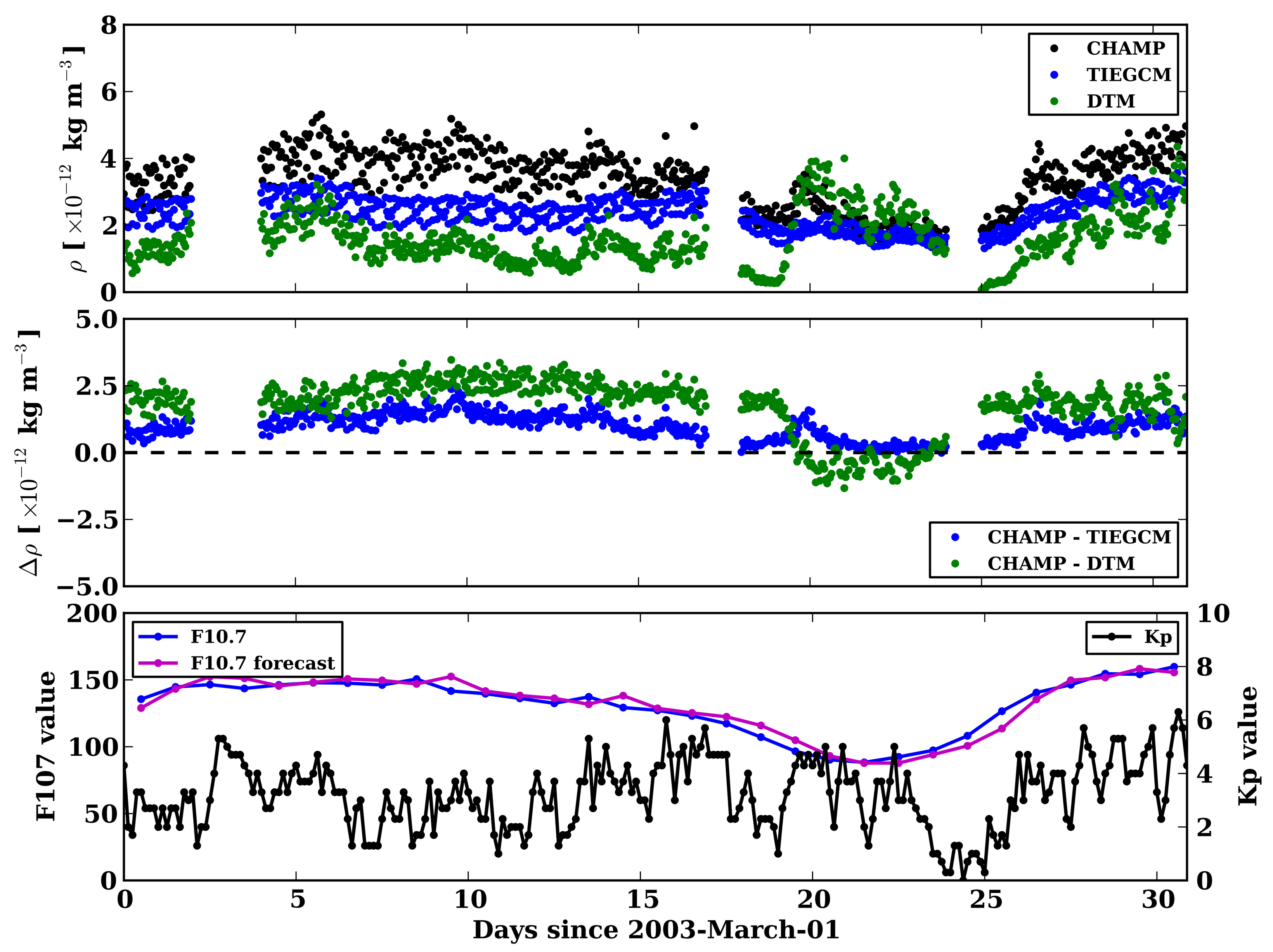

Figure 2: *Top: Hourly-averaged CHAMP, TIEGCM, and DTM densities for March 2003. Middle: Density difference between CHAMP and the two models. Bottom: Actual F10.7, forecasted F10.7, and Kp values (used as inputs to the models).*

- Both models are less accurate at solar max, generally underestimating the density. TIEGCM perform best overall, however DTM tends to mirror increases/decreases in CHAMP densities better.
- Using forecast proxies (not shown), a mean change of +2.8% is found for ρ_{TIEGCM}, +1.6% for ρ_{DTM}, and +0.6% for the F10.7 values.

5. Conclusions

- Both models perform well at solar min. Improvements to the models may be needed to reproduce stormy conditions better at solar max.
- The F10.7 forecast proxies developed in WP2 are accurate enough for operational use, not significantly changing model results.
- The inclusion of more satellite data in the DA (such as GRACE and GOCE) may improve results, as well as Incremental Analysis Updates.

References

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Contact

Email: sophie.murray@metoffice.gov.uk

Met Office FitzRoy Road, Exeter, Devon, EX1 3PB United Kingdom
Tel: 01392 885680 Fax: 01392 885681