Forecasting Solar and Geomagnetic Activity
for Atmospheric Density Models

Alan W P Thomson, British Geological Survey, Edinburgh EH9 3LA, UK (awpt@bgs.ac.uk)


Acknowledgements: David Beamish, Vivette Carlaw, Toby Clark, Ellen Clarke, Mike Firth, David Kerridge, Jess King, Sarah Reay, Pam White (BGS); Roberta Maggetti-Done, Heiner Alkraut, Dr. Kulgar & Rino Zandbergen (ESOC).

http://www.geomag.bgs.ac.uk/

What ESOC Wanted

Forecasts of the Solar EUV Proxy $F_{10.7}$ and the Geomagnetic Heating Proxy $A_p$

Used in MSIS Thermospheric Density Code to Determine Frictional Drag on Low Earth Orbit Satellites

Needed to Keep ERS1, ERS2 and now ENVISAT on a 1km Ground Track for High Quality Science Program

Better Forecasts and Low Drag Uncertainty = Better Orbit Management

Important for Satellite Lifetime & Re-entry Calculations, Collision Avoidance, Determining Fuel Requirements

BGS Association with ESOC

Geomagnetic and Solar Activity Studies & Index Prediction Software:

- Report on potential for improving forecasts of Ap and $F_{10.7}$ (e.g. solar active region correlation) and a simple satellite drag coefficient study (1993)
- Analysis of ERS1 and ERS2 thermospheric drag coefficient data: correlations with various solar and geomagnetic data and linear correction factors for Cd (2001)

Forecast Models Used by ESOC

Solar Cycle Predictions
'SOLMAG'
A Modified McNish-Lincoln Method.
Forecasts of monthly departures from the long-term smoothed monthly mean curve
Similar to Marshall Space Flight Center model

PDFLAP Performance Statistics
Accuracy to within a specified tolerance
±10 Units of Observed Value
Tolerances of better than ±10 for Ap and ±20 for F10.7 were said to be ‘desirable’ by ESOC

BGS Forecast Models Used by ESOC

1-27 Day Solar and Geomagnetic Activity Prediction
'PDFLAP'
Linear Auto-Regressive Models, estimated from last 730/180 days for F10.7/Ap – model selected by experiment
60/30 Coefficients for F10.7/Ap
Model Re-computed Daily
3rd and 30th Estimated by Least Squares

PDFLAP Performance Statistics
Accuracy compared to expected performance (from ESOC report of 1993)
Based on model tests on previous two solar cycles of data
**Improved PDFLAP Performance Statistics**

New forecast model for Ap:
- lags 1-3: neural net
- lags 4-6: climatology
- lags 7-15: PDFLAP
- lags 16-27: minimum forecast between PDFLAP and climatology

Not physically based therefore needs regular checking for accuracy and relevance

No improvement suggested here for F10.7

---

**The Future**

1. Monitor prediction accuracy throughout the next solar cycle
2. Better (more appropriate) data for correlating density variations with ground based measurements:
   - F10.7 as solar EUV proxy?
   - Real time global and local geomagnetic activity indices/data, e.g. midlatitude or auroral regions (e.g. **cast study**)
3. Potential for modelling improvements:
   - Incorporating cusp and other localized heating effects (e.g. in CHAMP data)?
   - Calibrating the thermosphere using real time satellite data e.g. USAF (last slide)

---

**Real Time Ap Estimates**

- Can now deliver real time indices and daily forecasts of activity
- Would welcome opportunity to contribute these data to ESA programs
Using the Correlations between Satellite Drag Coefficients and Solar and Geomagnetic Data to Reduce Drag Variability

Black line is original Cd with outliers removed.

Linear regression model:
Cd = Cd(Ap, PCN, Dst, HPN, HPS, Solar Distance)

Blue Line is Cd/Cd_TOT, i.e. taking into account the regression model.

Cd standard deviation is reduced to about two-thirds its uncorrected value on average and to about three-fifths during geomagnetic storms (Ap>40)

---

Poster - Ap in Real Time

Ellen Clarke (ecla@bgs.ac.uk), Alan Thomson (both at BGS, Edinburgh) and Hans-Joachim Linthe (GFZ, Postdam)

How is the Real Time Ap (see left) Derived?

How Accurate is the Real Time Ap? (see below)

Future Plans – Make Available via Swenet?

http://www.geomag.bgs.ac.uk/images/aphisto.jpg

---

ESA Space Weather Workshop (3-5 November 2003)