British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

19th-20th June 2014
3rd Swarm Science Meeting
Copenhagen, Denmark

VALIDATION OF SWARM SATELLITE MAGNETIC DATA USING OBSERVATORY MEASUREMENTS

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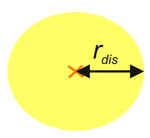
SUMMARY

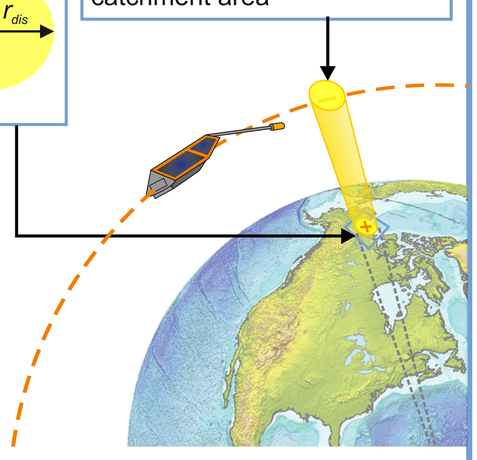
As part of the Swarm Calibration/Validation effort, we have exploited the long-term accuracy of observatory data to ground-truth Swarm measurements. We present the results compared with those obtained when a similar analysis is carried out for CHAMP.

1. APPROACH

Radial distance from each observatory defined at Earth's surface and projected to satellite altitude using simple conical angular projection



Consider measurements on ground and from Swarm when a satellite passes through the catchment area



r_{dis} = 120 km balances number of passes over time with maximum distance from observatory (smaller r_{dis} = fewer passes = more difficult to obtain meaningful statistics)

Comparing ground and observatory measurements

- More passes from high latitude observatories owing to r_{dis} definition
- Cannot be compared directly due to main field secular variation, different proximity to external field sources & satellite manoeuvres
- Instead analyse *each pass* relative to *all passes* over that observatory
- Basic processing chain:
  1. Remove core field from pass measurements using degree 20 BGS main field model
  2. Linearly detrend grouped satellite and grouped observatory data
  3. Calculate difference between satellite normalised measurement and observatory normalised measurement at each pass, α :

satellite data from pass; satellite mean; observatory data from pass; satellite mean from all passes

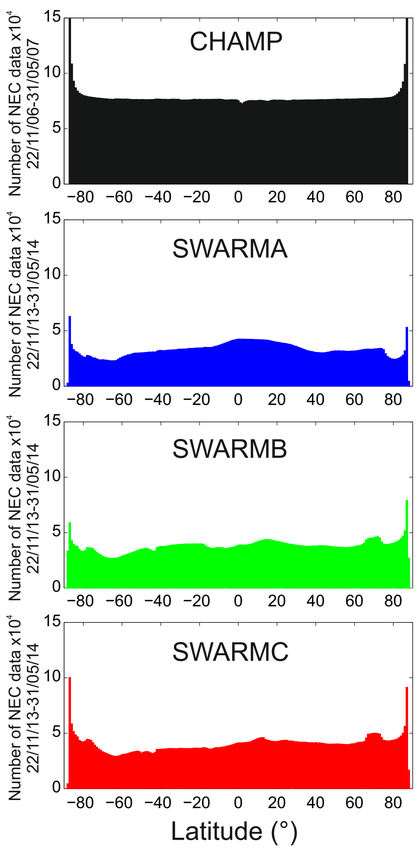
$$\alpha = \left| \left(\frac{B_{sat} - \bar{X}_{sat}}{\sigma_{sat}} \right) - \left(\frac{B_{obs} - \bar{X}_{obs}}{\sigma_{obs}} \right) \right|$$

satellite standard deviation; satellite standard deviation

SELF-NORMALISING: α is only large if there is a discrepancy in EITHER the satellite or observatory data - NOT BOTH

2. DATA

Analysis carried out over 193 days for nominal (unflagged) NEC data with:
a) SWARM A, B and C from 22/11/2013-31/05/2014 & quasi-definitive observatory minute data (QDD)
b) CHAMP from 22/11/2006 - 31/05/2007 & definitive observatory minute data

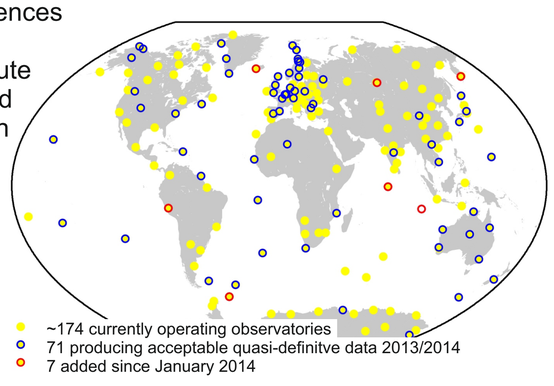


Satellite data:

- 1-second CHAMP and Swarm data employed, but averaged over the pass trajectory after main field removal
- Plots show distribution of nominal data with latitude
- Little variation in CHAMP altitude over period of investigation vs. numerous Swarm manoeuvres

Observatory data:

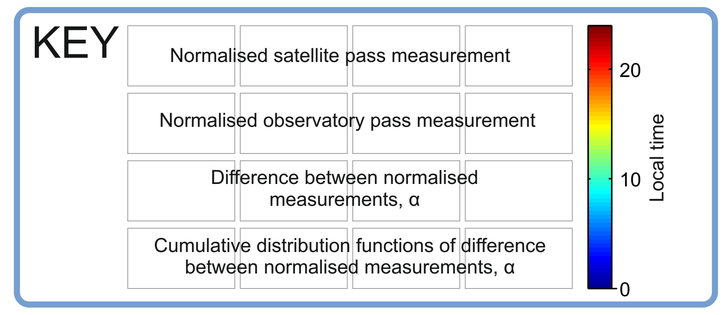
- QDD = submitted to INTERMAGNET within 3 months of measurement with accuracy close to that of definitive data (98% of differences between QDD and definitive NEC minute mean values should be less than 5nT on a monthly basis)
- The map shows locations of all observatories producing QDD or close-to-definitive data in a timely manner



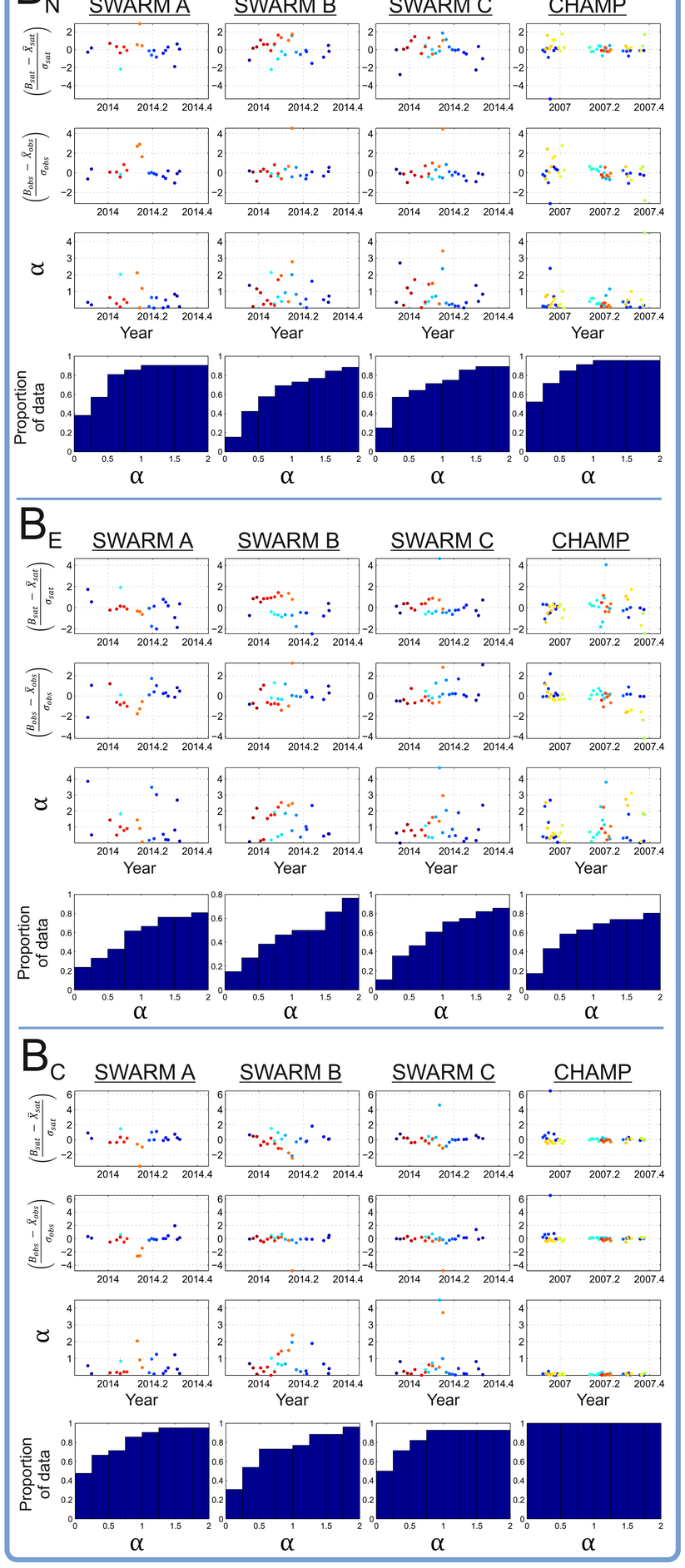
3. EXAMPLE: SATELLITE PASSES OVER ABK & ESK

- Plots below show the analysis in B_N, B_E and B_C for two observatories: ESK (Eskdalemuir, 55°N 357°E) & ABK (Abisko, 68°N 19°E)
- Dot colour indicative of local time
- For these examples:

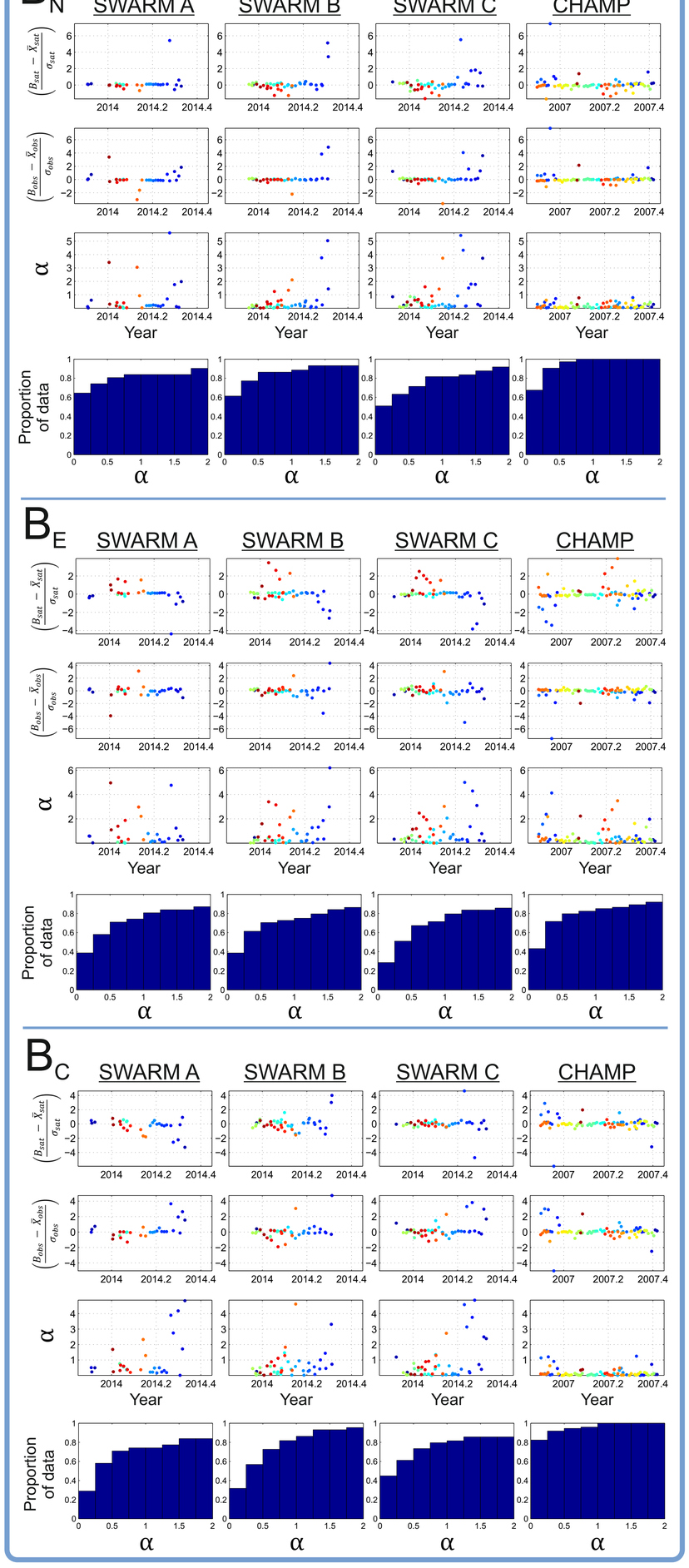
1. Similar results seen for all Swarm satellites
2. Similar results to those seen for CHAMP, but CHAMP passes generally show lower α with very few passes at α>2
3. No large difference between B_N/B_E/B_C and no clear trend with local time



ESK



ABK



4. COMBINED ANALYSIS & CONCLUSIONS

- Analysing the cumulative distribution function of α for individual observatories provides ambiguous results
- Instead we calculate the mean cumulative α distribution for all observatories where there have been ≥10 passes in the investigatory period, with nominal data available for both Swarm and CHAMP
- 30 observatories meet these criteria
- The mean distributions are far more uniform between satellites, than that seen for individual observatories, but in all cases α→0 for CHAMP in a slightly larger proportion of passes
- There are several possible reasons for this, but the most likely relate to difficulties in constructing the $\bar{X}_{obs}$, $\bar{X}_{sat}$, σ_{obs} and σ_{sat} statistics as a result of:
  - Fewer pass data from Swarm
  - Satellite manoeuvres changing proximity to unmodelled **B** sources
  - Higher external disturbance levels for Swarm interval