Technical University of Denmark

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Kotsiaros, Stavros; Plank, Gernot; Haagmans, R.; Olsen, Nils

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Towards diagnostic tools for analysing Swarm data through model retrievals

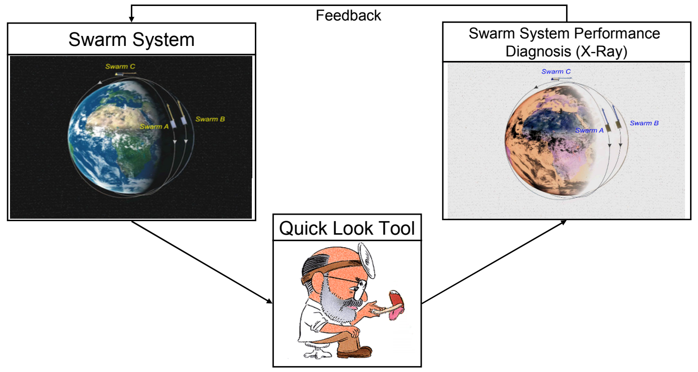
Stavros Kotsiaros[1](Stavros.Kotsiaros@esa.int), Gernot Plank[1], Roger Haagmans[1], Nils Olsen[2]

The Swarm satellite mission

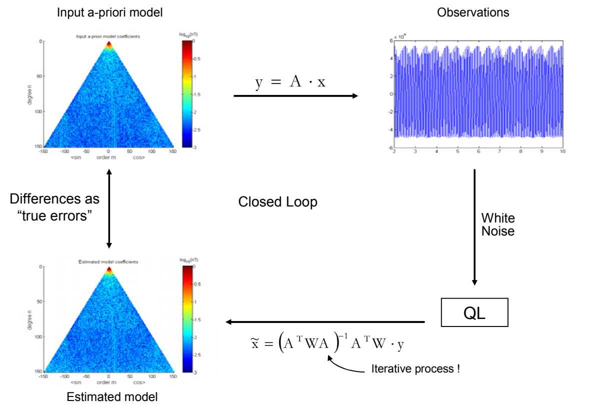
The objective of the Swarm mission is to provide the best ever survey of the geomagnetic field and its temporal evolution, and gain new insights into improving our knowledge of the Earth's interior and climate. The Swarm concept consists of a constellation of three satellites in three different polar orbits between 490 and 530 km altitude. High-precision and high-resolution measurements of the strength and direction of the magnetic field will be provided by each satellite. In combination, they will provide the necessary observations that are required to model various sources of the geomagnetic field. The launch date is foreseen in October 2010. The planned operational lifetime is 48 months, after a 3-month commissioning phase. Analysis of the Swarm data will greatly improve existing and provide new models of the near-Earth magnetic field of high resolution and authenticity compared to a single-satellite mission. This will provide the prospect of investigating hitherto undetected features of the Earth's interior.

Quick-look tool

- Data Validation tool for the Level 1B data
- Fast diagnosis for the Swarm system performance
- Fast feedback of the quality of produced data during commission phase and operations of the spacecraft
- Static field only
- Single satellite approach
- Least squares adjustment
- Approximative solution strategy

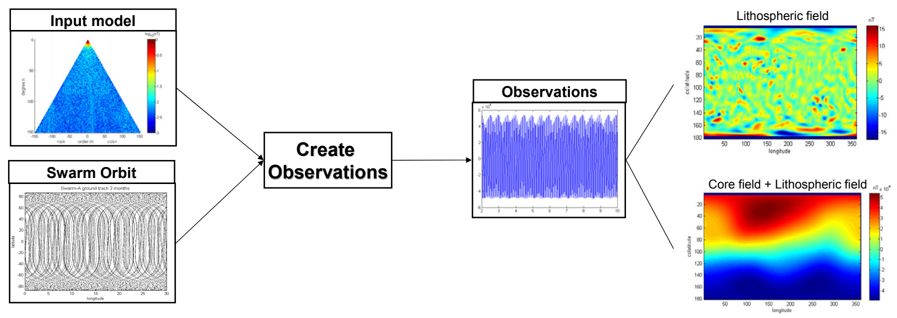


Closed loop simulation



- Investigation of the effects on the reconstruction of the static core and lithospheric magnetic field resulting from various error sources
- QL uses iterative approach, i.e. Conjugate Gradient
- Two major cases investigated:
  - Lithospheric field retrieval
  - Core and Lithospheric field retrieval
- Three different scenarios investigated for each case
- Different noise levels applied for each scenario (white noise)

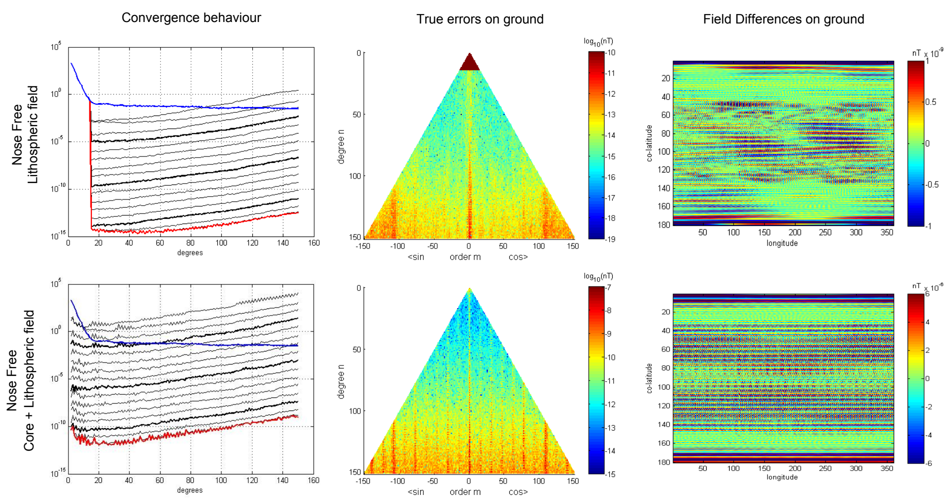
Simulated observations



- Observations created from:
  - Input a-priori model
  - Swarm Orbit
- Observations for:
  - lithospheric field
  - core and lithospheric field

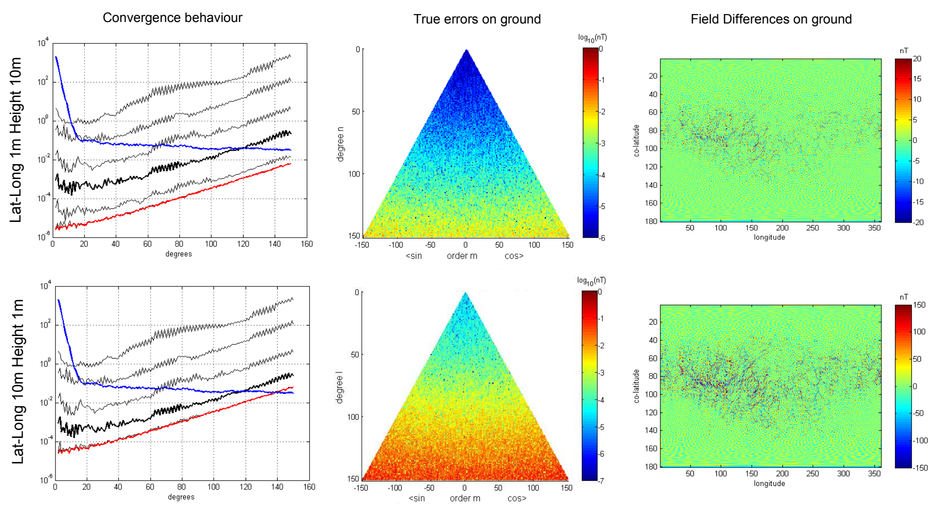
- Input a-priori model:
  - swarm 06/04, DTU-Space
- Swarm Orbit:
  - lower simulated orbit, DTU-Space
  - 3 months
  - 15 sec sampling rate
  - further extension to a multi-satellite approach

Noise free case



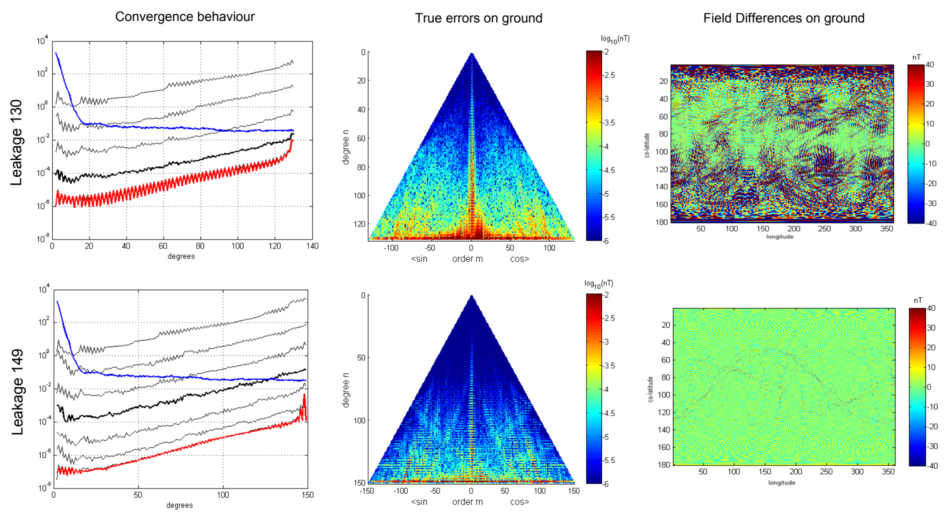
- ⇨ Enhanced error structures above order 100 in the simple case (poor spatial resolution)
- ⇨ Enhanced error structures in the zonal coefficients (polar gap)
- ⇨ Higher true errors when the core field is included (Core – lithospheric field coupling)
- ⇨ Enhanced error structures at certain orders (Swarm orbit daily revolution frequency)

Position error case



- ⇨ Uniform distribution of errors
- ⇨ Gradual degradation with increasing degree
- ⇨ Bigger impact of latitude-longitude error against height error (axial symmetry of core field)
- ⇨ Deteriorated lithospheric field retrieval accuracy (core – lithospheric field coupling)

Spectral leakage



- ⇨ Stronger energy shift in the higher degree estimated coefficients
- ⇨ Enhanced true errors in the zonal coefficients (axial symmetry of the core field)
- ⇨ Worse retrieval quality of odd zonal coefficients against even zonal coefficients
- ⇨ Smaller spectral leakage impact if estimated for higher degree values

Conclusions & Outlook

The Quick Look tool software package could provide a fast diagnosis of the Swarm system performance during the commission phase and operations of the spacecraft. At first only the Earth's lithospheric field is considered and at second the core field is also included. For each case closed loop simulations are performed covering three different scenarios. The noise free scenario generally demonstrates that the Quick Look software package works. The model is reconstructed fast and with good accuracy in both cases. The core – lithospheric field coupling imposes a worse retrieval accuracy in case the core field is included. Furthermore, the poor spatial resolution of the observation dataset created is reflected as enhanced true error structures in the higher order values, whereas the polar gap is reflected as enhanced true error structures in the zonal coefficients for the noise free scenario. On the other hand, the position error applied is separated into latitude-longitude and height error. Again the coupling between the core and lithospheric field but also the relative magnitude of the core against the lithospheric field impose a deterioration of the retrieved accuracy of the lithospheric field. Due to the axial symmetry of the core field, the latitude-longitude error has a bigger impact in the retrieval quality than the height error, but for both error types the true errors are uniformly distributes across all orders with increasing degree. Finally, in the spectral leakage test runs the model is estimated up to lower degree values compare to the input model and thus the effects of the energy shift from the un-estimated coefficients to the estimated model is investigated. As expected, the energy shift is more intense for lower estimated degree values, affecting more the higher estimated degree coefficients. At last, the odd zonal coefficients appear to be more affected by the spectral leakage than the even zonal coefficients.

1 ESA, Mission Science Division
2 DTU - Space