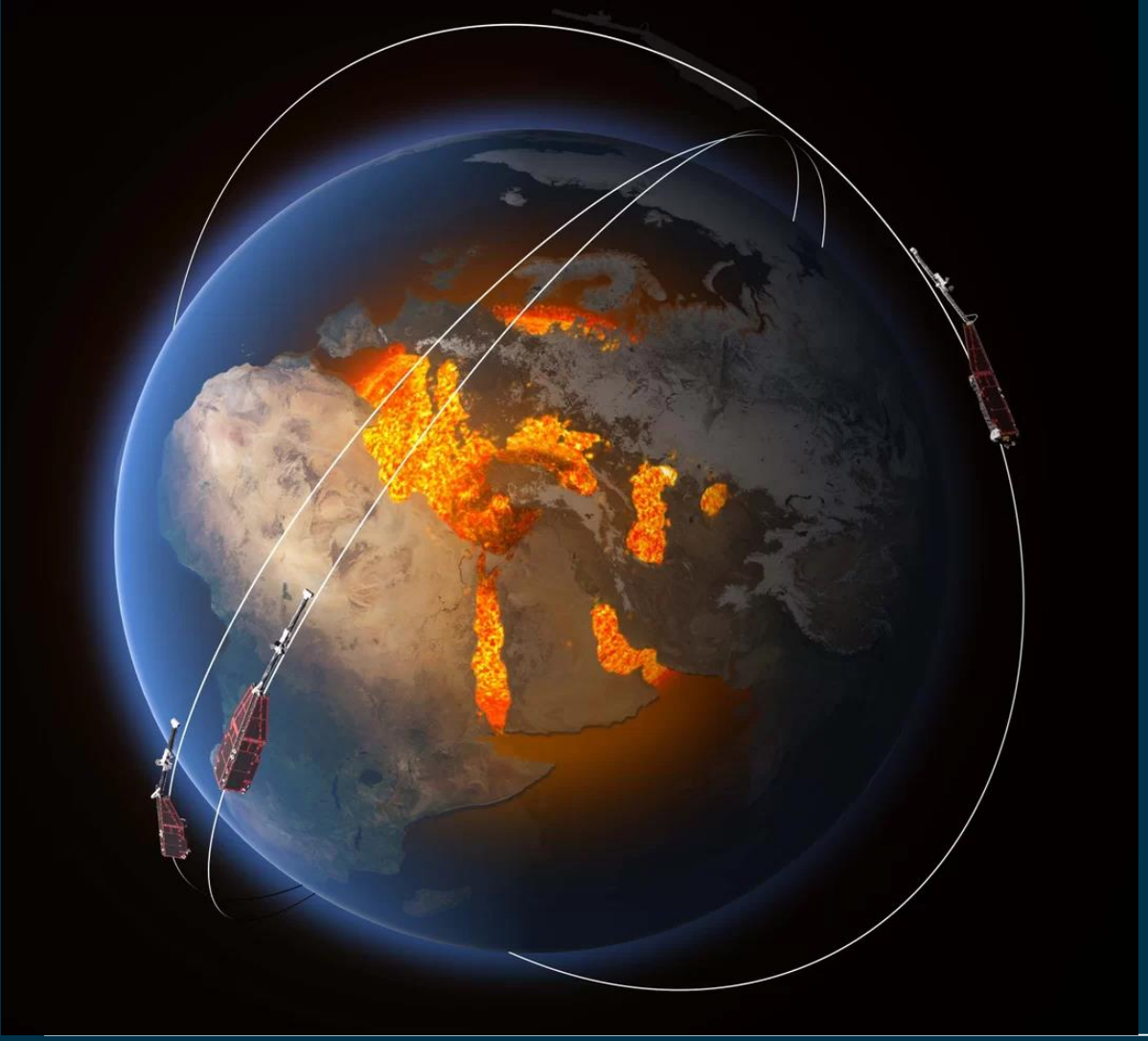
Summaries, Recommendations & Future

15th October 2021

Session 2

Magnetic field measurements

11th October 2021



Session #2 Magnetic Field Measurements

Summary & Recommendations

Swarm 11th Data Quality Workshop
11th – 15th October 2021, Athens, GR

Session 2: summary & recommendations

Main topics:

Magnetic instruments status and improvements

Swarm new baseline investigations

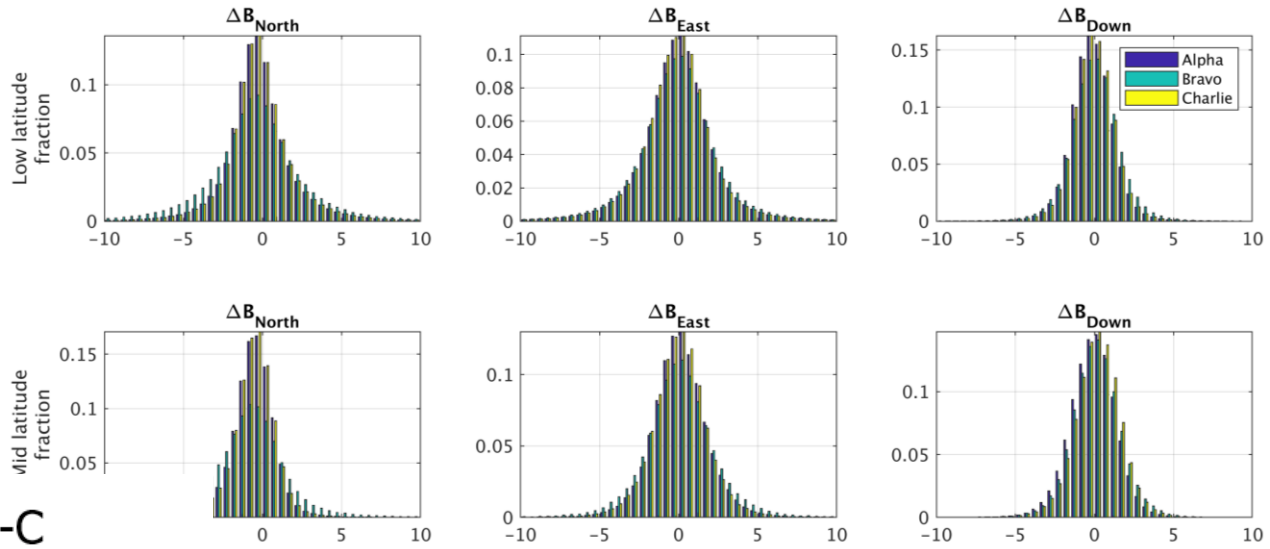
ASM improved Vector and burst mode datasets

Swarm Echo MGF dataset

Session 2: Magnetic field measurements	**Chairs: Nicola Comparetti / Jan Miedzik**
Magnetic package instruments and processors	Nicola Comparetti
New correction scheme for dB_Sun in Level 1b	Lars Tøffner-Clausen
Investigations of Swarm Euler Angles Using the CHAOS field model	Chris Finlay
A tiny -almost imperceptible- error in satellite magnetic field at magnetic equator? Real or artifact?	Angelo De Santis*
Coffee break	
Swarm ASM Burst mode L1b data	Pierre Vigneron*
On the improved experimental ASM vector mode data	Gauthier Hulot
The New Swarm-Echo Magnetic Field Data Product	David Miles
In-situ calibration of the Magnetic Field Instrument on Swarm-Echo	Robert Broadfoot*

Swarm magnetic package status and improvements

- STR, ASM, VFM: excellent performances
- Main improvement in latest baseline:
  - introduction of dB_Sun,ASM →
  Pretty well description of sun induced disturbance
- New baseline used to derive CHAOS-7.8 field model + estimation Euler angles



Credits: Lars Tøffner-Clausen, DTU

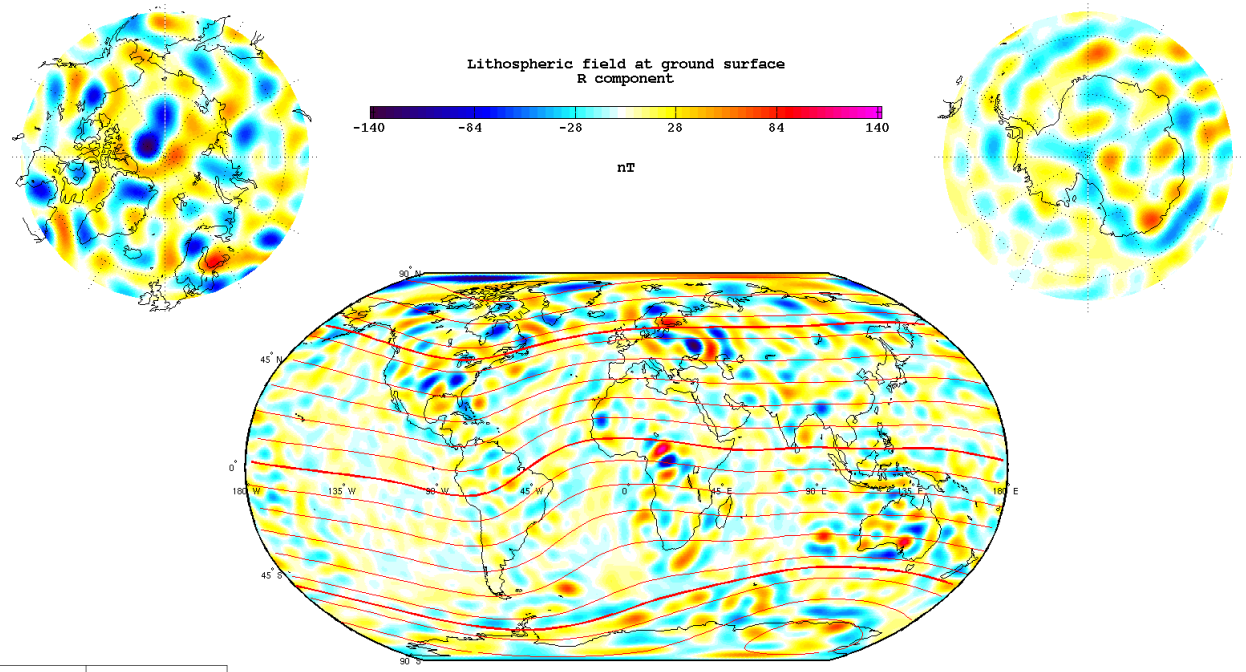
		SW-A		SW-B		SW-C	
[arcsec]		mean	rms	mean	rms	mean	rms
0601	2	-0.67	5.23	0.89	5.12	2.07	5.56
	3	1.27	**14.68**	-4.74	**14.15**	-8.19	**16.52**
	1	0.47	6.64	-0.06	7.93	-0.87	7.00
05	2	0.88	5.36	1.13	5.16	2.13	5.51
	3	1.10	**15.71**	-4.51	**24.47**	-8.29	**17.84**
	1	1.47	7.12	1.72	10.46	-0.41	7.24
0601-05	2	-0.21	0.72	-0.24	0.88	-0.05	0.82
	3	0.17	**12.44**	-0.23	**19.39**	0.10	**7.52**
	1	-1.00	3.67	-1.78	5.91	-0.47	2.31

Credits: Chris Finlay, DTU

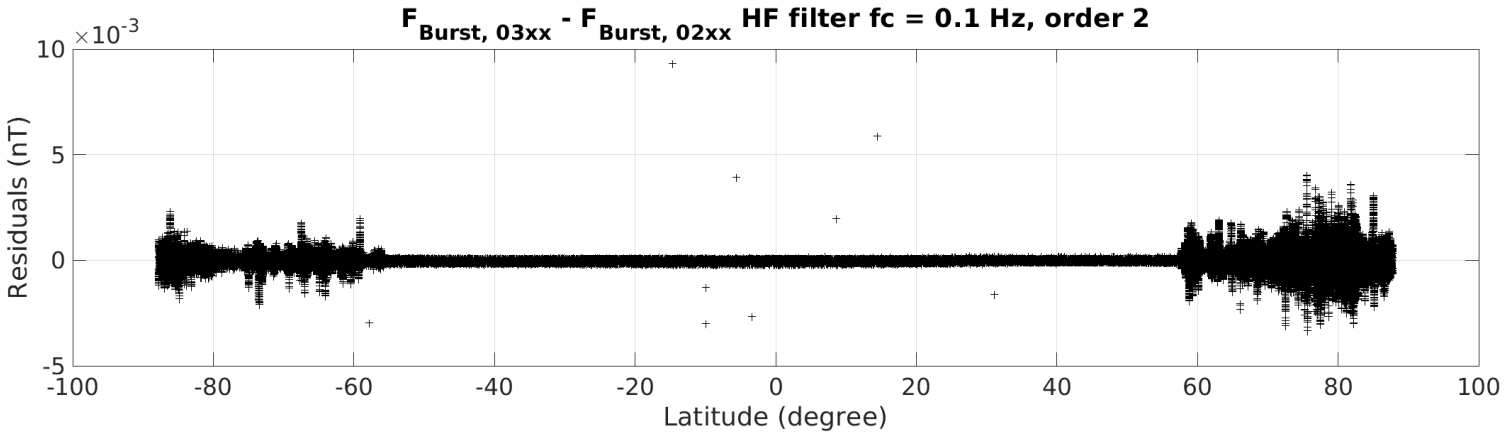
High quality ASM-V and Burst Data

- ASM-V data version 050X show great quality:
  - improved self calibration
  - allows to build reliable global field models

- Burst mode data version 0201 great quality:
  - Meant to be used for high frequency studies



Credits: Pierre Vigneron, IPGP

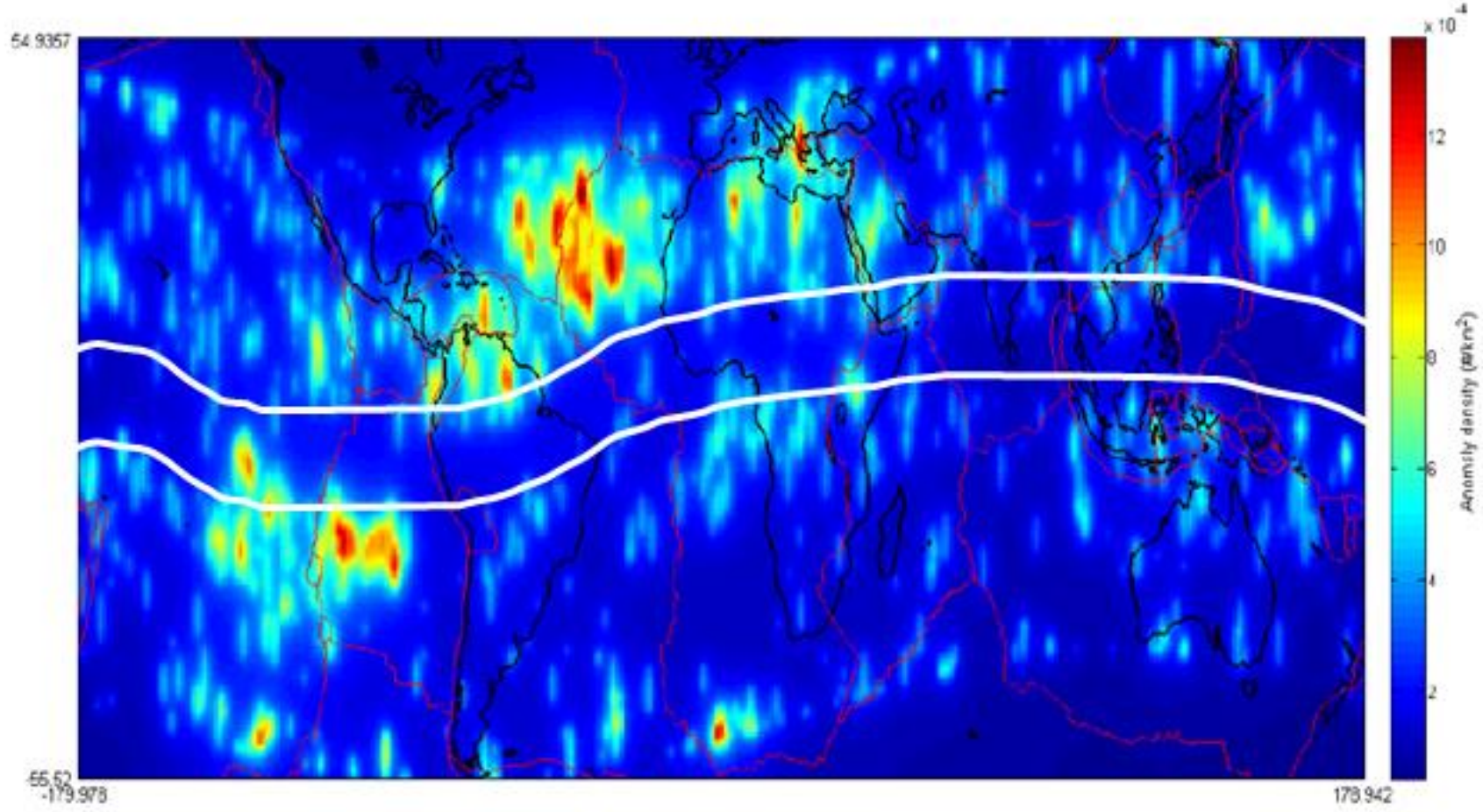


Credits: Gauthier Hulot, IPGP

Swarm magnetic data at equator very smooth

Analysis of worldwide Swarm and CHAMP data

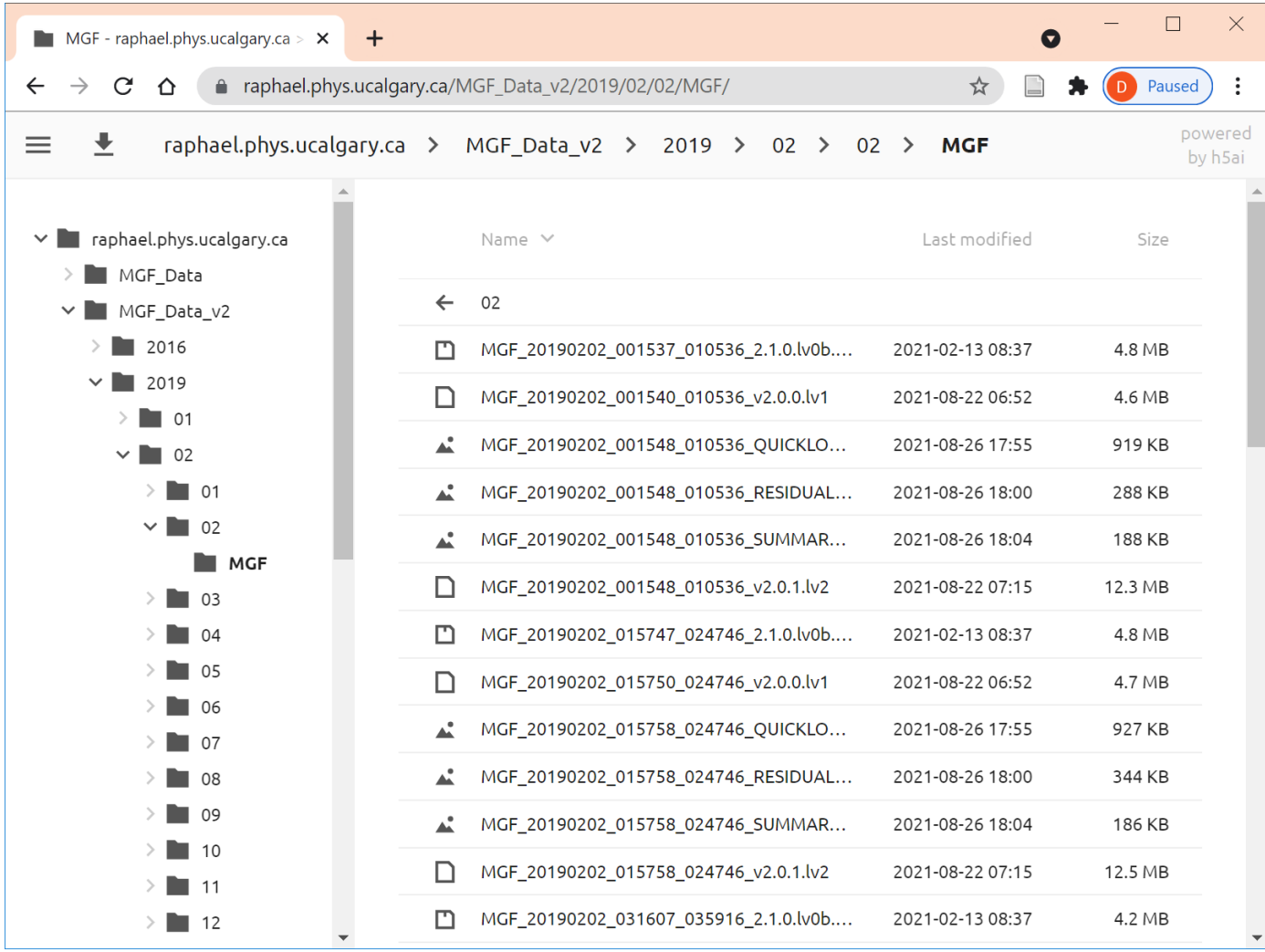
- Suppression of tiny fluctuations (~1nT) by the L1B algorithms to process VFM data at the equator?
- Anomalies disappears also with CHAMP data



Credits: Angelo De Santis, INGV

Swarm Echo MGF data

- Improved attitude solution, metadata, flagging, and 7-day in-situ calibration
- Best data is between 2016 and 2021 due improved attitude data and attitude coverage
- Data already available at https://raphael.phys.ucalgary.ca/MGF_Data_v2/



Credits: David Miles and Robert Broadfoot, University of Iowa

Recommendations

- Short term
  - Endorsement from DQW#11 Community to go into operation with new L1B product baseline and release the reprocessed dataset on Q1-2022.
  - keep current Euler angles in the operational chain
  - Continue to operate in Burst mode 1 week / month / satellite → open to the whole Swarm community
  - Release Swarm-Echo MGF data covering 2016-2021
- Longer term:
  - IPGP to generate and distribute ASM-V data version 06 to account for new dBSun,ASM correction
  - IPGP to process and release future Burst sessions version 0301 including new dBSun,ASM model
  - Keep Swarm Echo as part of Swarm constellation? → action plan to assess the quality of the data after reaction wheel failure
  - Consolidate the list of evolutions to be include in future L1B processing baseline
  - Implementation of a Swarm fast processing chain

Swarm Fast Data Production – On-going Analysis

PHASE I - Analysis

- Assess that the IPF are able to process in a data driven approach
- Confirm availability of alternative Auxiliary Data
- Generate a 3-days Test Dataset of L1B data
- Update QC & validation diagnostics for quality assessment
- Characterise error introduced in regards to nominal processing.
- Identify L2 product and potential users which would benefit from fast production

PHASE II - Feasibility

- Integrate (modified) IPF into a parallel chain
- Configure retrieval of alternative Auxiliary Data
- Generate off-line 1 year L1B Dataset (tbc 1 or all SpaceCrafts) as if it had been done on-line, i.e. Evaluation Dataset
- Provide Evaluation dataset to select users and collect feedback.
- Perform an overall quality assessment (up to L2 data samples processed offline by related experts).

PHASE III - Demo

- Systematic Fast Data production for all Spacecrafts, for 3 to 6m.
- Initially only L1b, after check also L2-CAT2.
- These would be disseminated to select users, i.e. the Demonstration Datasets.
- Collect user feedback and consolidate.
- Confirm data quality and user interest (up to L2 data samples processed offline by DISC experts).

PHASE IV - Routine

- Systematic Fast L1b Data production for all Spacecrafts.
- Revised dump approach – e.g. predefined dump intervals per spacecraft.
- (TBC) Increased number of passes – from 2 to 3 or more.
- Extend to some selected L2 products following same logic and steps (current L2 and future products from Space Weather project)

Session 3

GPSR and accelerometer

12th October 2021

GPS and accelerometer instrument and data session:

Summary and recommendations

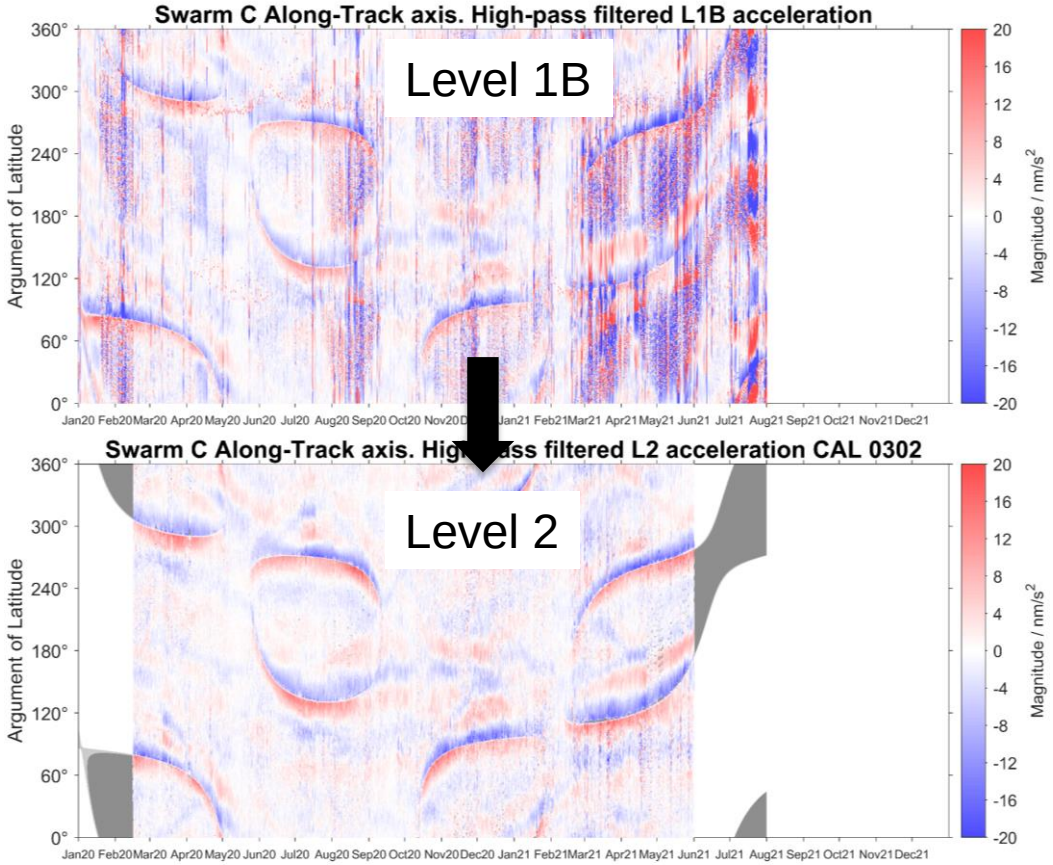
Christian Siemes & Elisabetta Iorfida

Swarm 11th Data Quality Workshop

Online, 11–15 October 2021

TU Delft

Accelerometer Level 1B → 2 processing

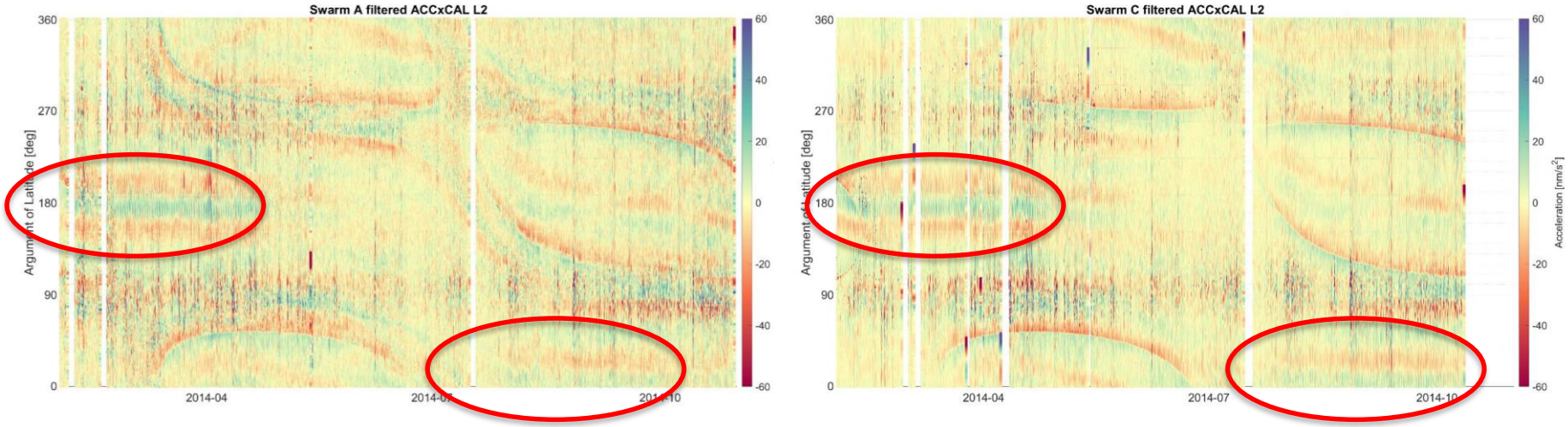


Cleaning of accelerometer data is crucial

Cleaning tools have evolved to be very effective

Credits: Sergiy Svitlov, LU Hanover

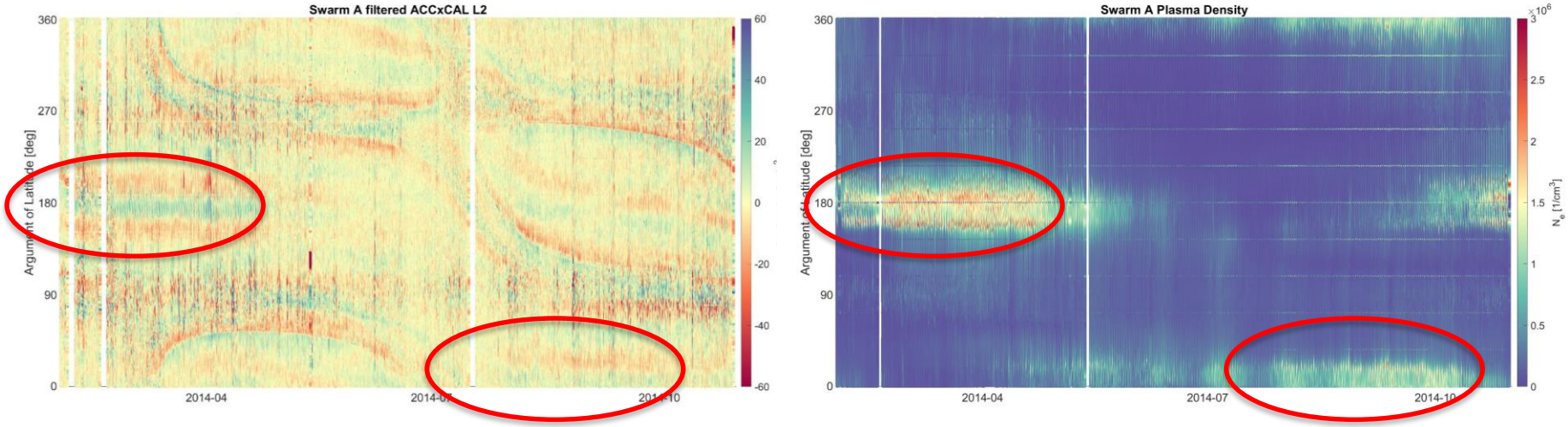
Swarm A vs. C Level 2 accelerometer data



Credits: Elisabetta Iorfida, ESA

New cleaned and calibrated acclerometer dataset from Swarm A allows to identify common ***signals*** (noise are not common)

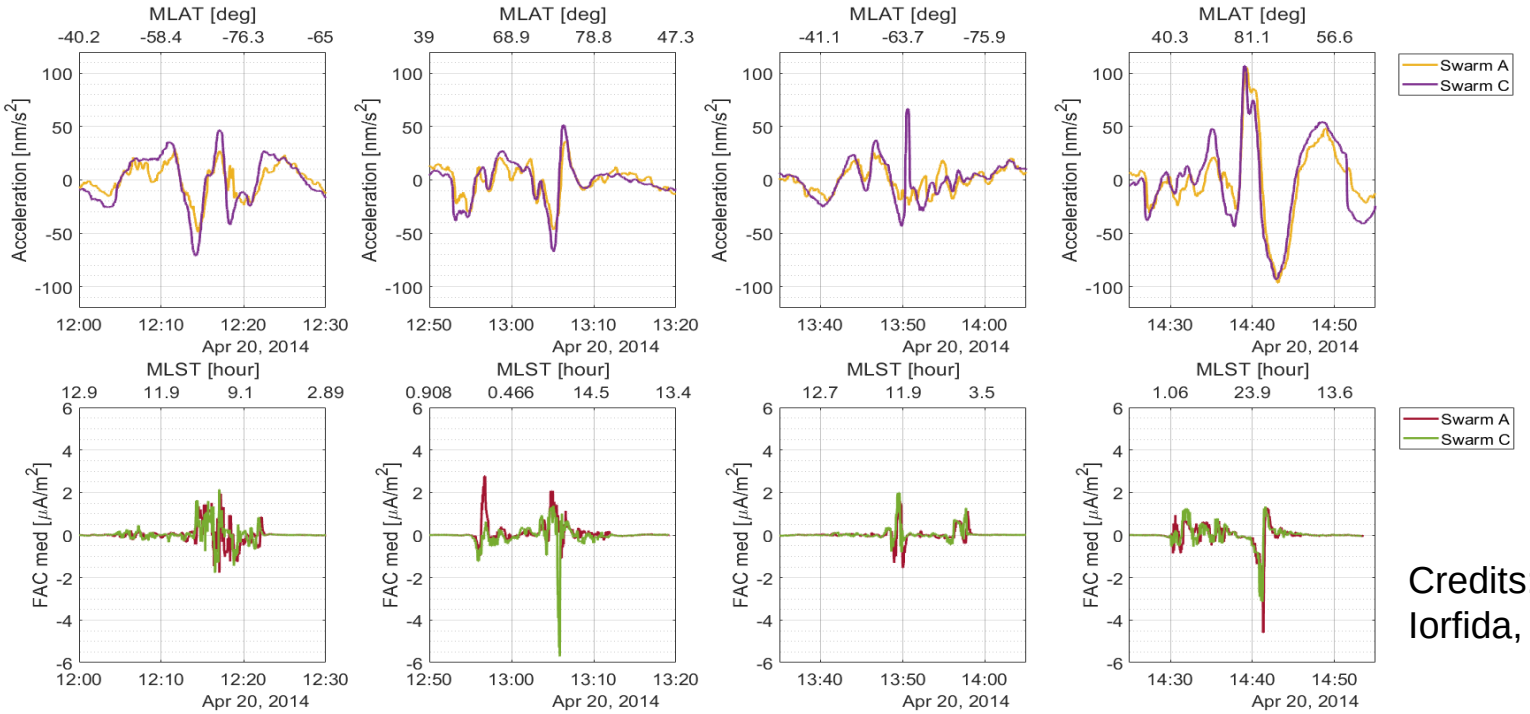
Swarm A vs. C Level 2 accelerometer data



Credits: Elisabetta Iorfida, ESA

Coupling between equatorial ionization anomaly and equatorial mass anomaly?

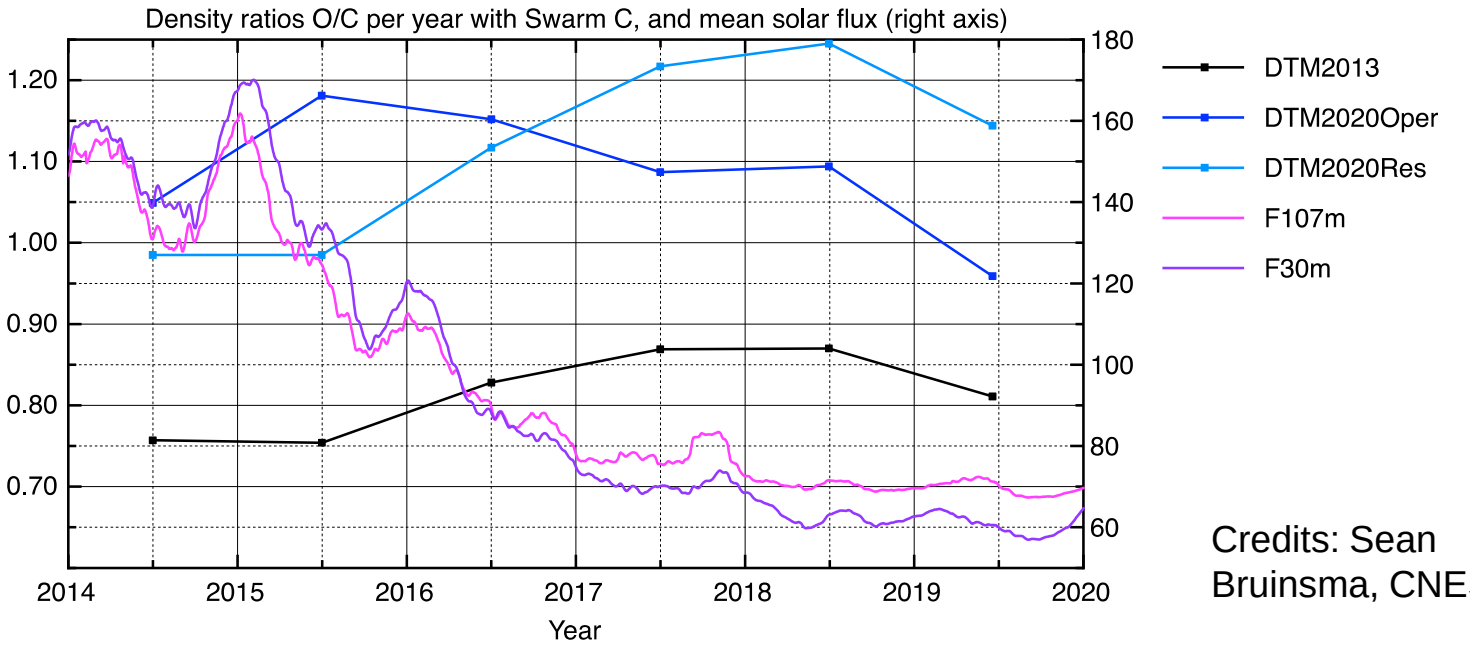
Swarm A vs. C Level 2 accelerometer data



Credits: Elisabetta Iorfida, ESA

Dual-satellite observations increase confidence in study of magentic forcing of the neutral atmosphere, e.g. Joule heating

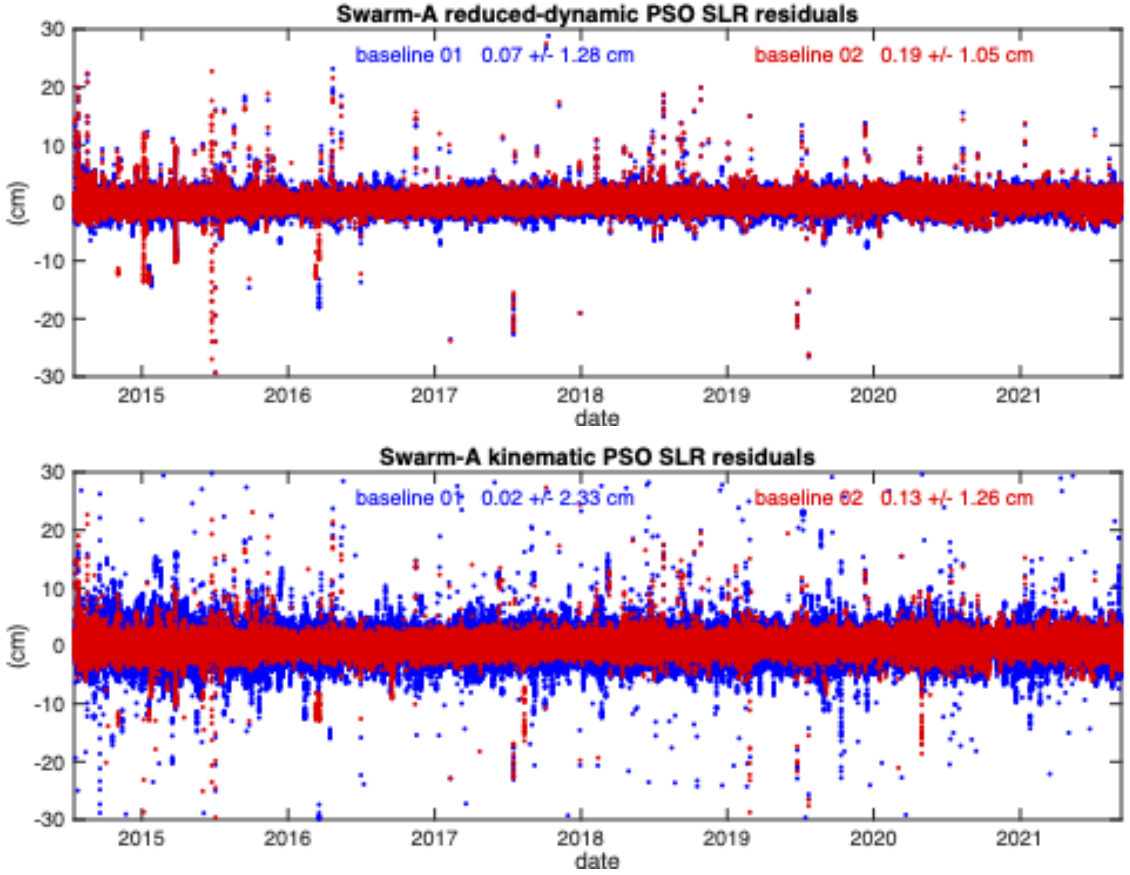
Neutral density observations vs. models



Credits: Sean Bruinsma, CNES

Swarm POD-derived density observations helped improving thermosphere models, in particular reducing biases

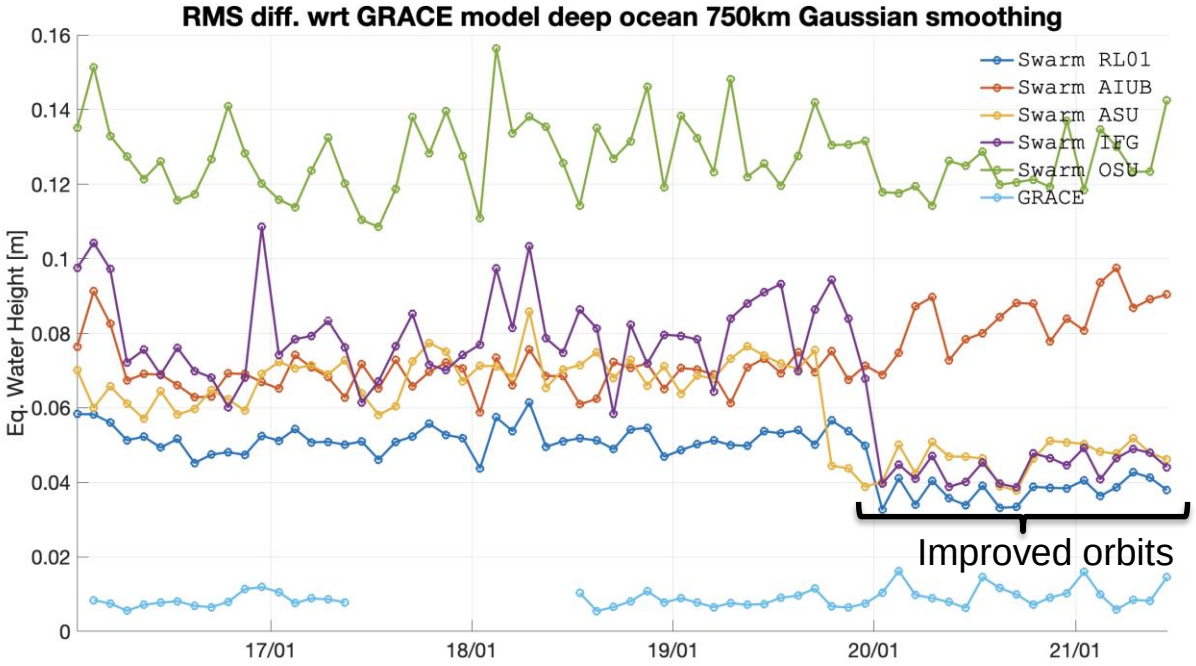
New baseline for Level 2 precise orbits



New baseline of precise orbits with increased accuracy (confirmed by validation using SLR data)

Credits: Jose van den IJssel TU Delft

Swarm gravity field models



Credits: Joao Encarnacao, TU Delft

Combination of Swarm gravity field models from different groups reduces the “analysts’ noise”

Summary and recommendations

Continue efforts to further enhance cleaning of accelerometer data

Swarm A accelerometer data

- Adds value by constrating signals from artifacts
- Extend time series as much as possible to support scientific analysis

Reprocessing of Swarm gravity field models recommended to fill the gap between GRACE and GRACE-FO with improved accuracy

Assimilation of POD-derived density observstions in DTM

- Swarm A: Not only medium-high solar activity, but all data
- Swarm B: Consider assimilation after upgrade of radiation pressure model

Swarm GPS receivers do not track GPS Block III satellites

- Discovered during the DQW → under investigation

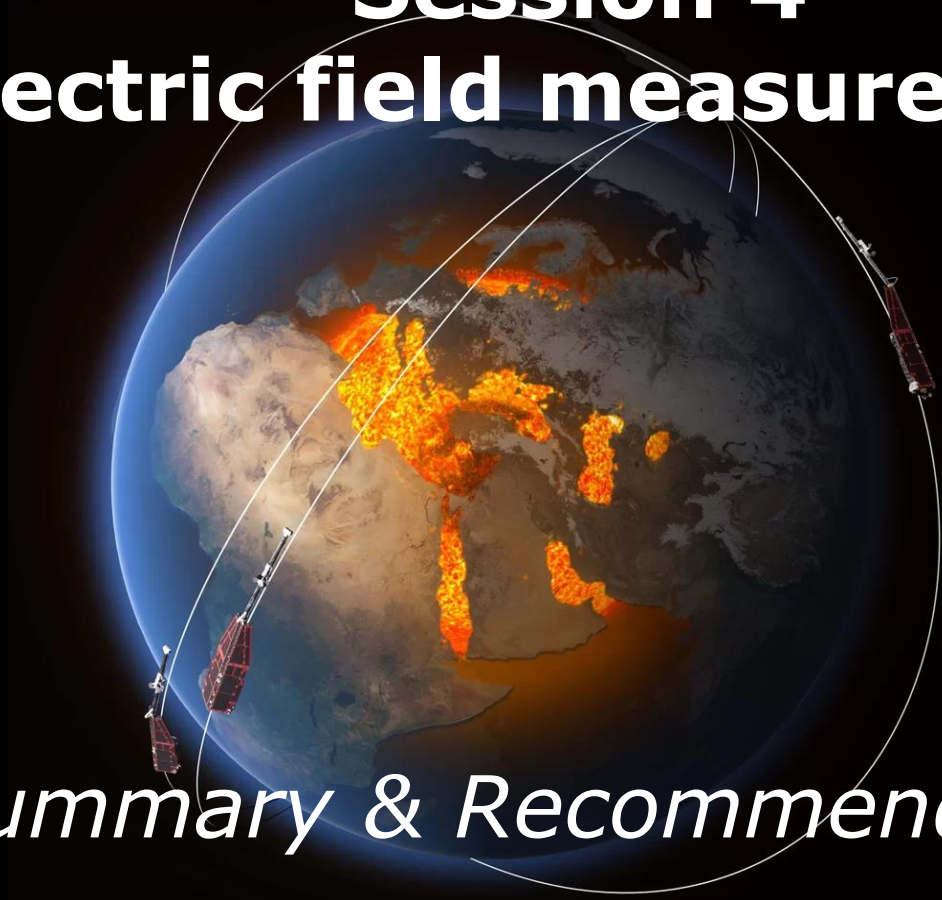
TU Delft

Session 4

Electric field measurements

12th October 2021

Session 4
Electric field measurements



Summary & Recommendations

Roberta Forte

Swarm Data Quality Workshop #11
Athens 11th – 15th October 2021

EFI-LP status and processor

- **PLASMA product baseline 0502** (L1B OP v03.22) currently in operation since February 2020.
- New **PLASMA product baseline 0601** released to the DQW community for **endorsement** on July 2021. (covering from BoM to August 2021)

L1B OP v03.24p3 (baseline 0601)

- new values **Ne_error** and **Te_error** are released based on the **estimation of the systematic error by "Lomidze" method:**

  Ne_error = $N_{e\,L} - N_e$

  (Where $N_{e\,L}$ is determined using ISRs measurements)

  See Lomidze et al. (2018) **https://doi.org/10.1002/2017RS006415**

- Discarding **N_e** or **T_e** or **V_s** , if corresponding Flags_Xx>=30

L1B OP v03.25

COMING NEXT:

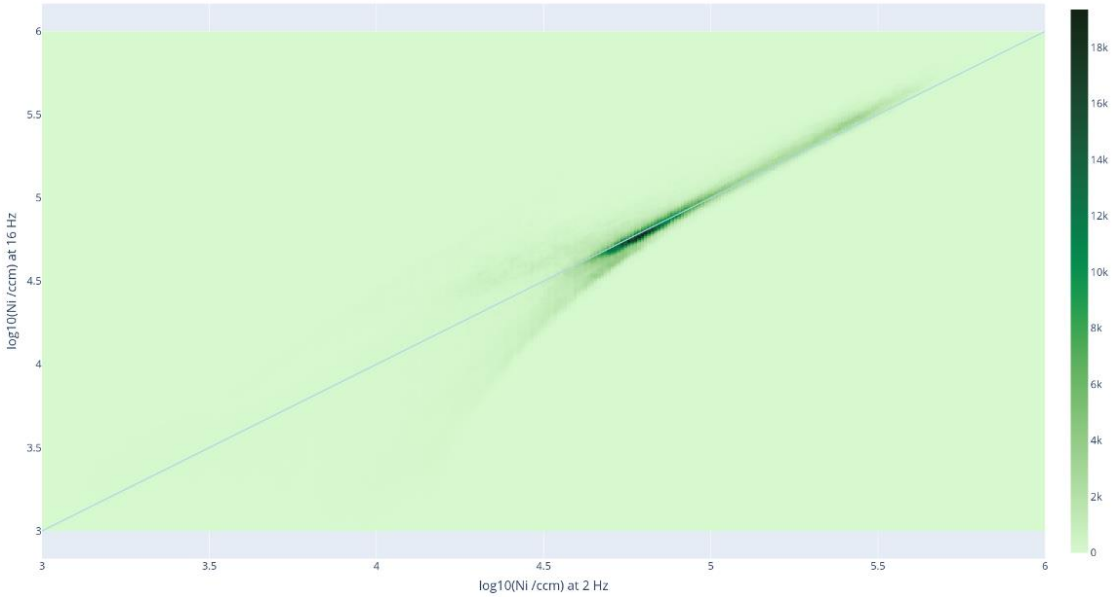
- rename Ne -> **Ni** , ion density;
- Set Te_error and Ni_error = 9.999e9;
- Add **dNi cal, dTe cal**
- add **Ne**, estimated electron density, with corresponding dNe_cal, Ne_error;

The Swarm LPs, status and results

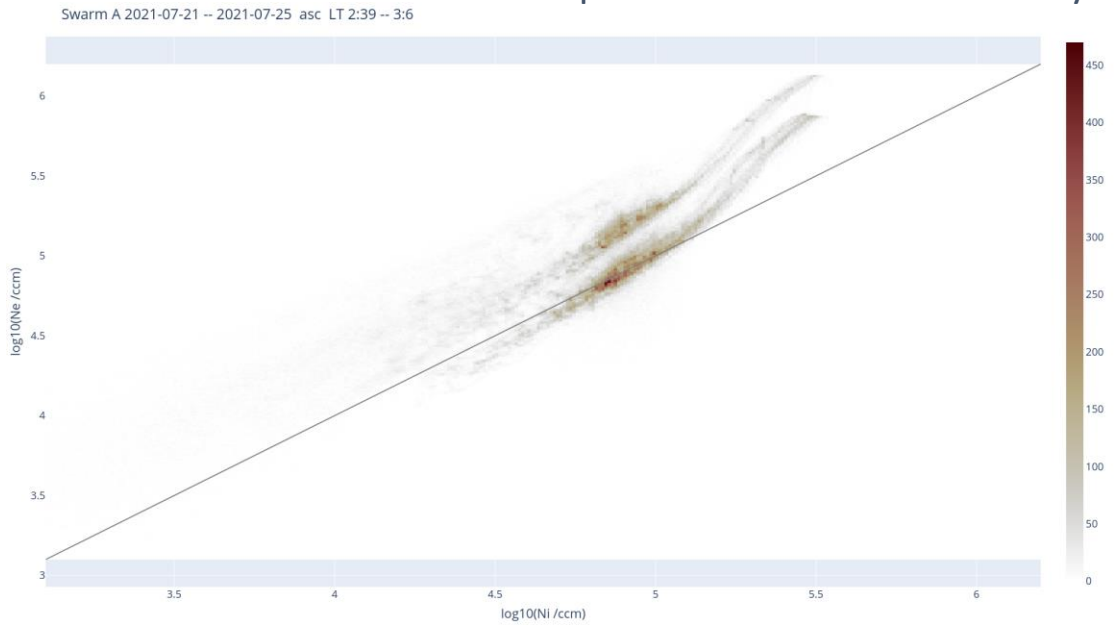
Presented by
Stephan Buchert

- Swarm LPs provide near uninterrupted Ne, Te, Vs since 7 1/2 years;
- Ne, Te and Vs are estimated in HM at 2 Hz rate (LP);
- Ni is estimated at 2 Hz rate (LP) and also at 16 Hz from the current through the FP.

Comparison 2Hz and 16 Hz Ni



comparison Ni and Ne over 5 days



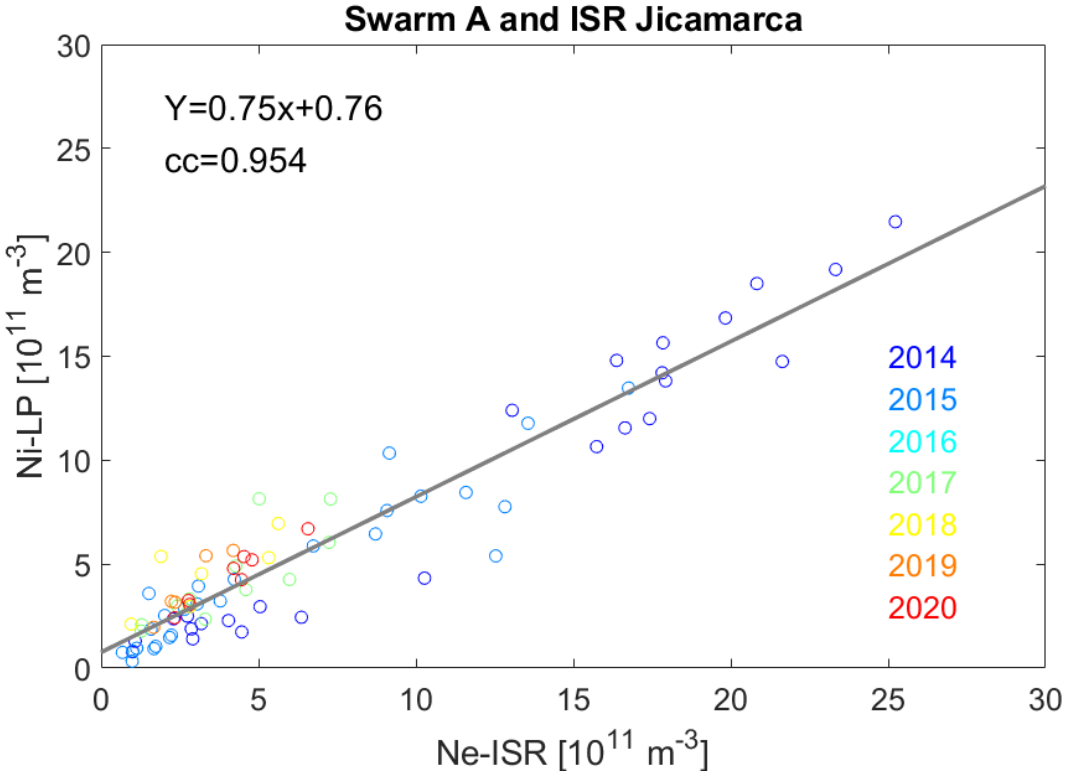
Ne and Ni can be different, but not in the Earth F region (observed differences have with certainty instrumental causes)

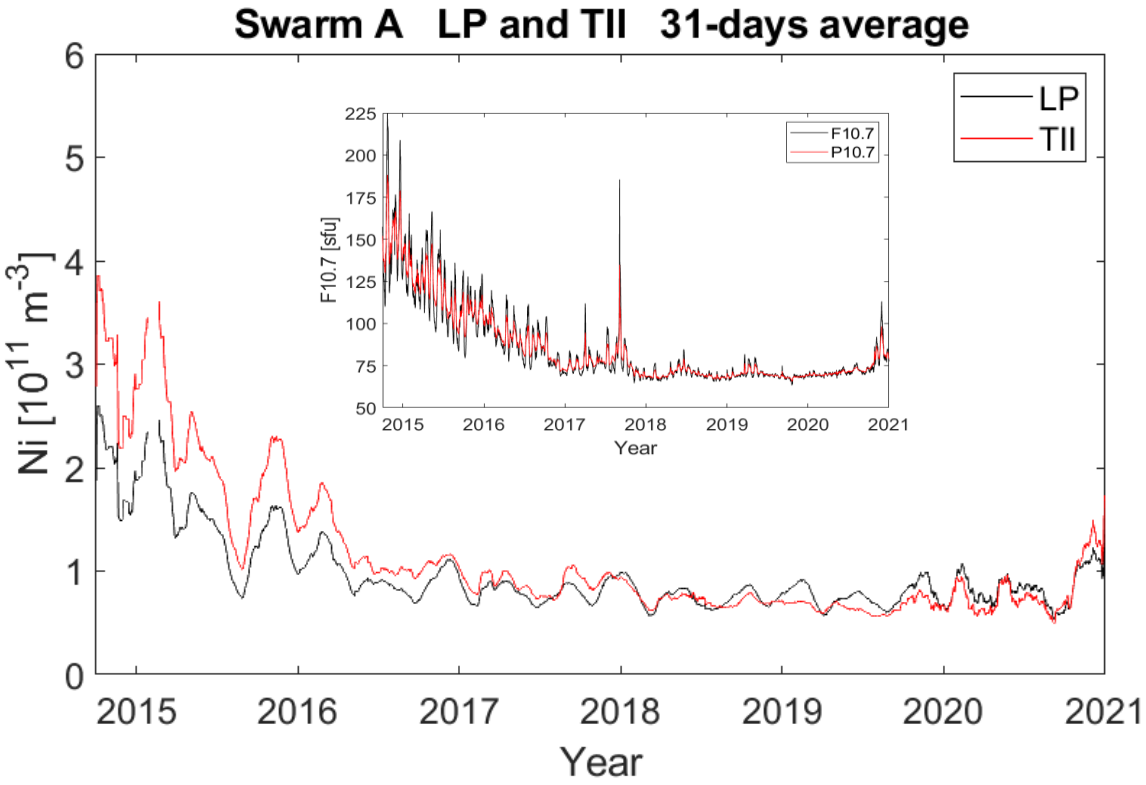
More cross calibration needed between Ni and Ne

Revalidation of plasma density measured by the Swarm LP

Presented by
Chao Xiong

- Cross-calibration on *Ni* measures suggests that there is a trend of the ratio on solar activity level.





A **solar activity correction factor**, derived for the Swarm *Ni* data, which could be included in the Swarm future processor.

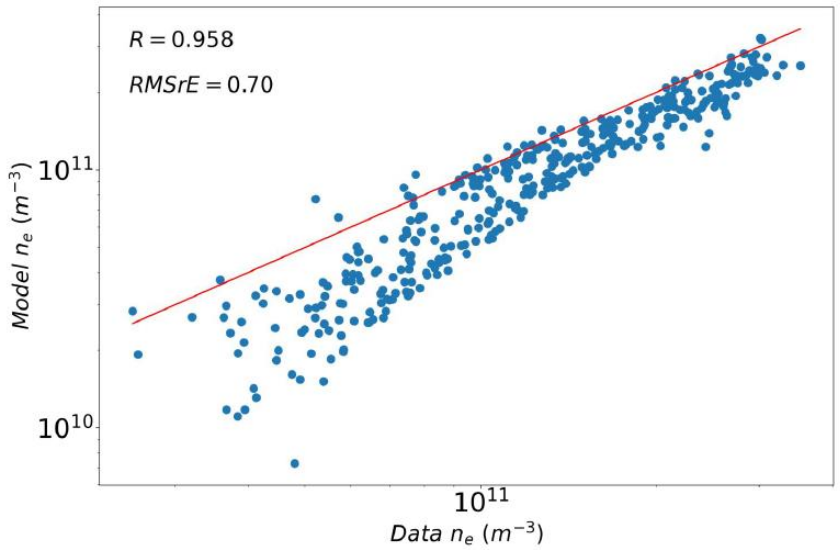
Inference of Swarm Langmuir probe measurements with machine learning techniques

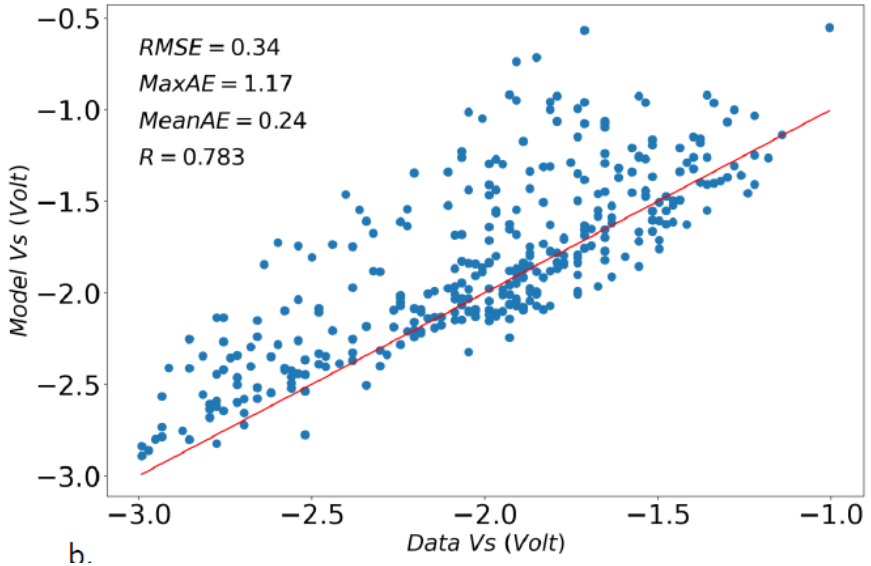
Presented by
Akinola Olowookere

A **new machine learning** approach to determine LP products based on:

- Application of Radial Basis Function (RBF) in the prediction of plasma parameters

- Combination of Analytic and RBF approach (RBF + OML approximation)





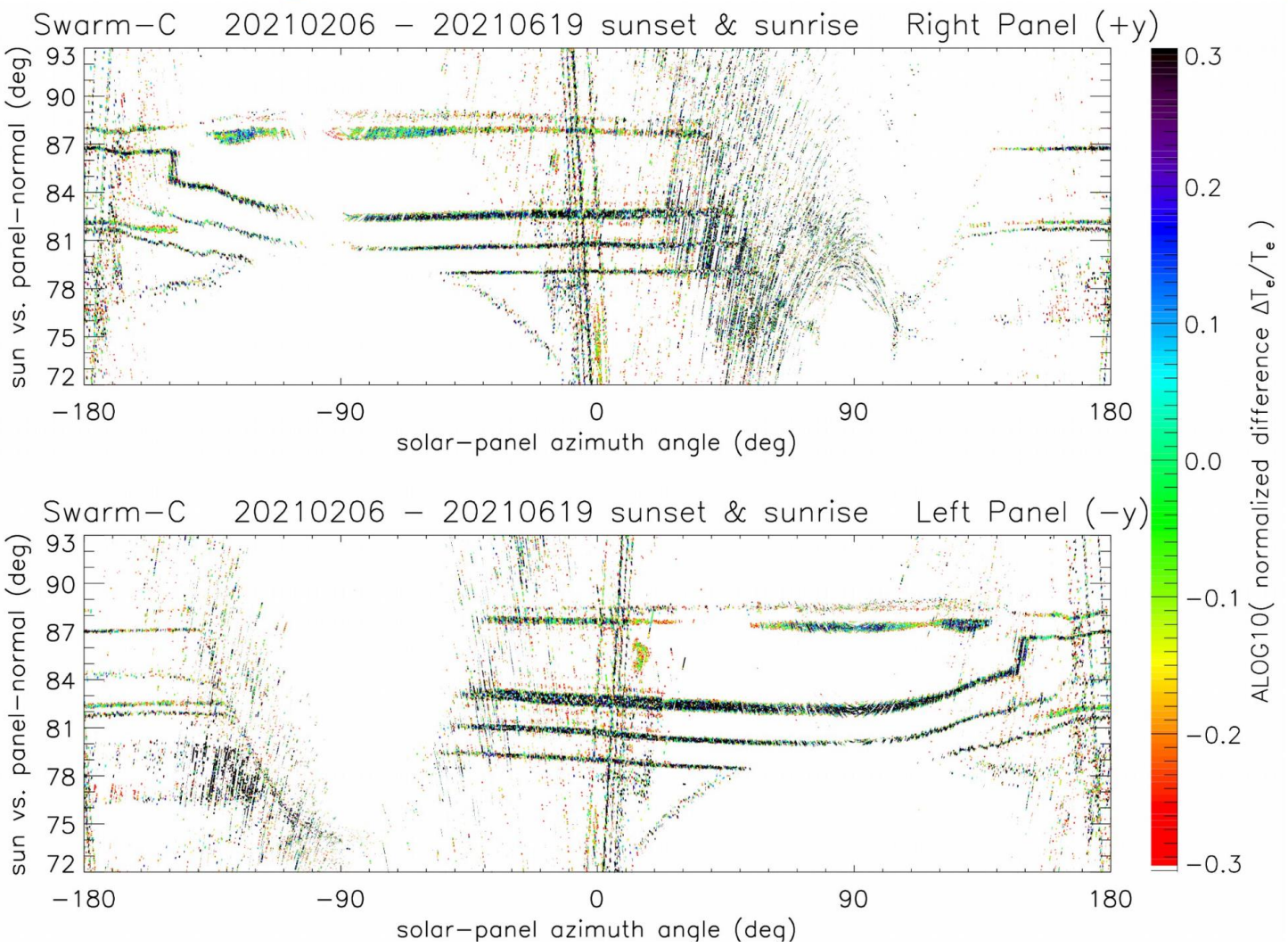
b.

Models trained with synthetic data can be used to infer plasma and satellite parameters in good qualitative agreement with reported values from the Swarm data portal.

But measurements of Ne, Te, Vs are needed to accurately ascertain the skill of the models.

Spike-trains in electron temperature measured from Swarm Langmuir probes (SPETTRALE project)

Presented by Matthias Förster



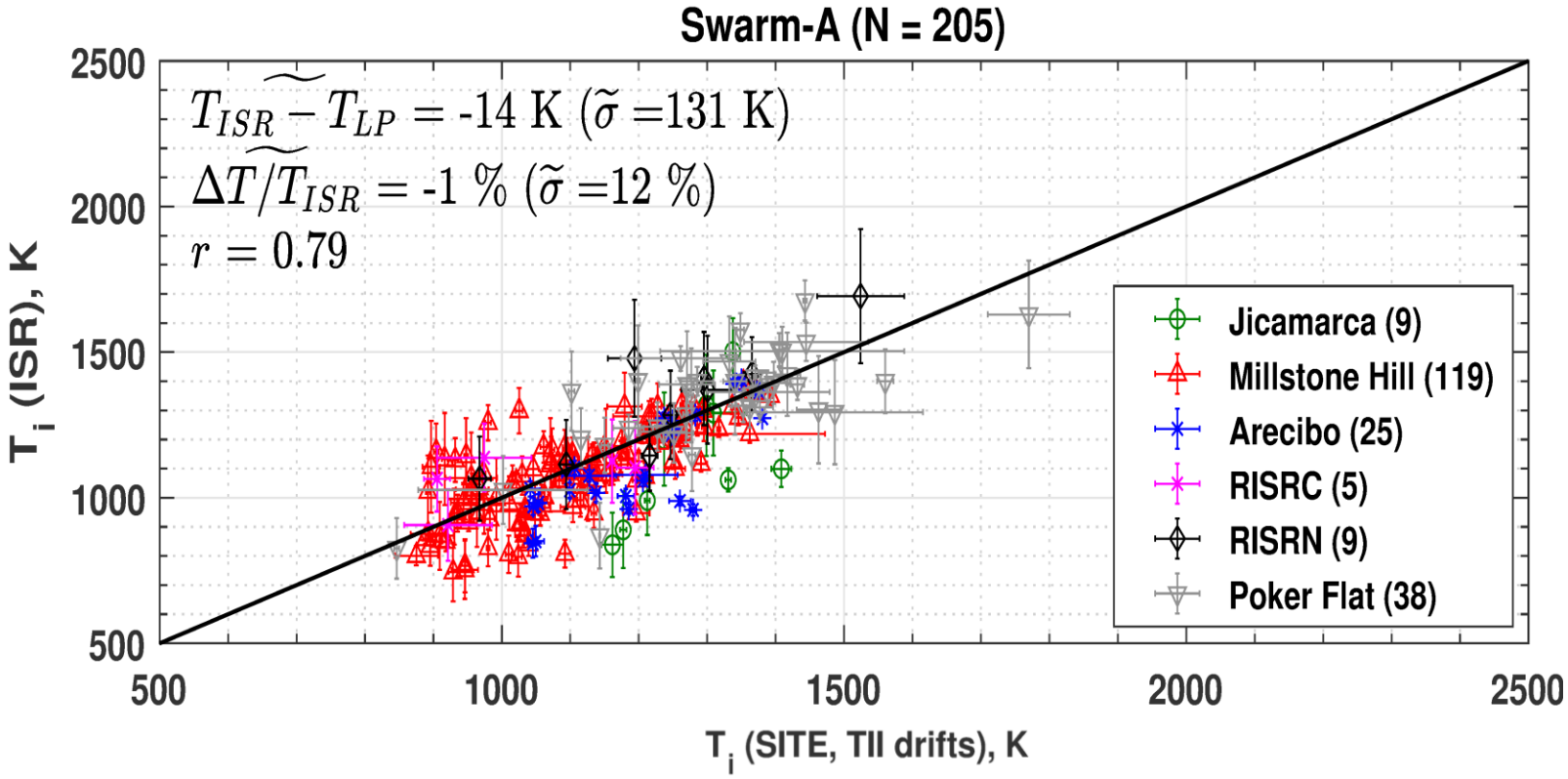
Swarm C, Te spike trains, chunk 11 ascending

- Artificial **Te spikes** occurrence is related to specific orientation of solar panels with respect to the sun.
- A detailed investigation on HK data from solar panels is ongoing.
- The aim of this project is to define a new algorithm to **new quality flag** the artificial Te spikes.

Swarm EFI Science Update

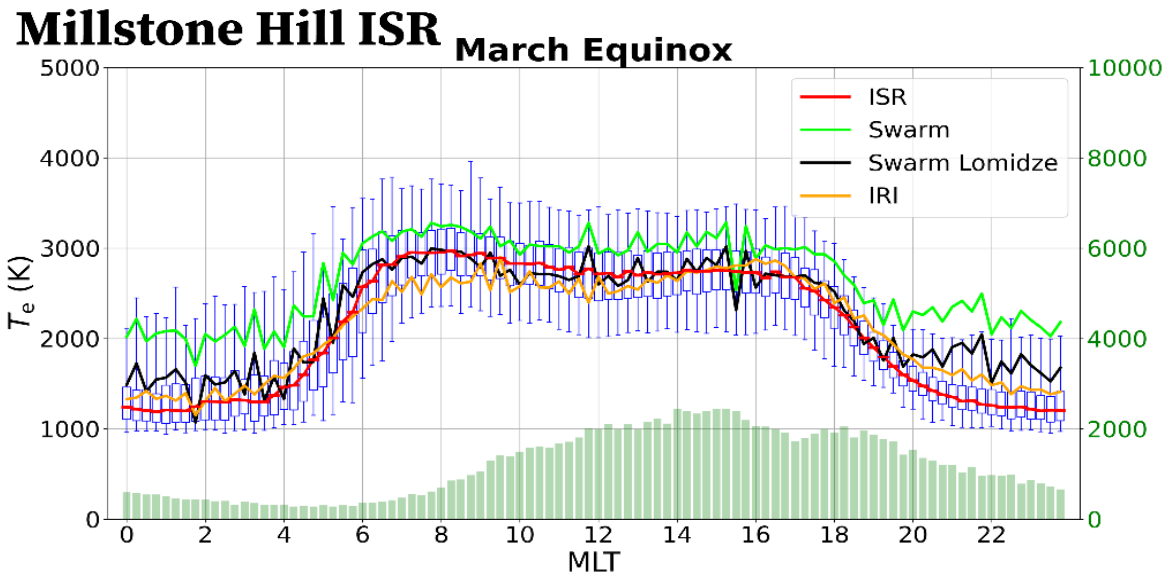
Showed by
David Knudsen

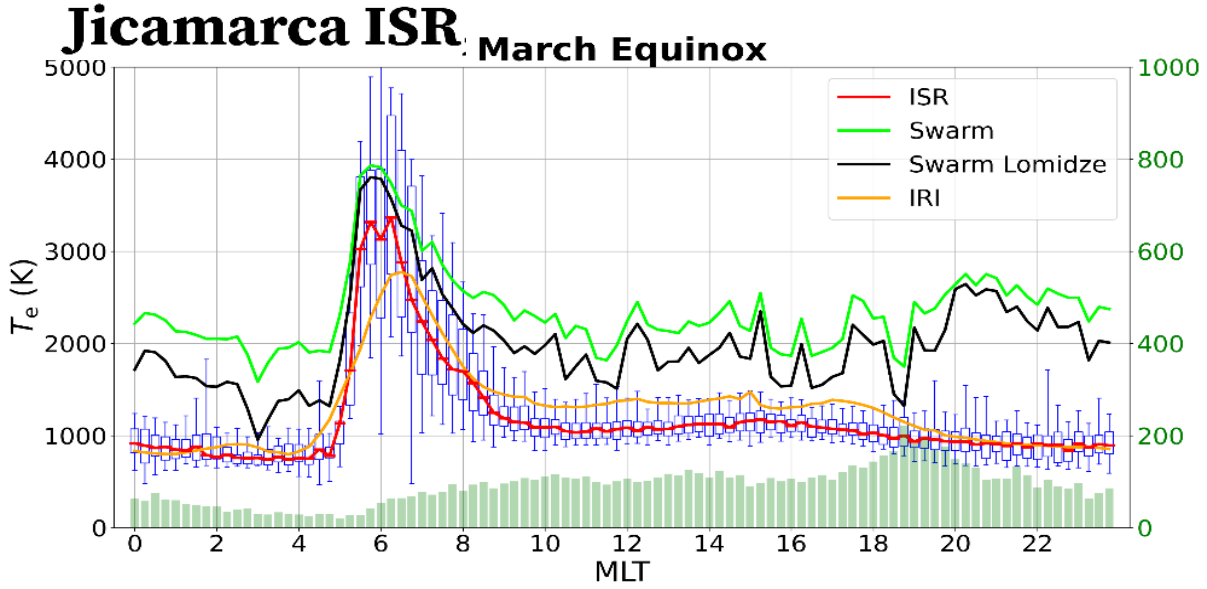
Swarm Ion Temperature Estimate



By solving the energy equation for ions, from LP data it is possible to infer **Ion temperature**, which is also in good agreement with **ISR measurements** during Swarm overflights.

Lomidze, L., J.K. Burchill, D.J. Knudsen, J. Huba, Estimation of Ion Temperature Along Swarm Satellite Orbits, Earth and Space Science, in review, 2021





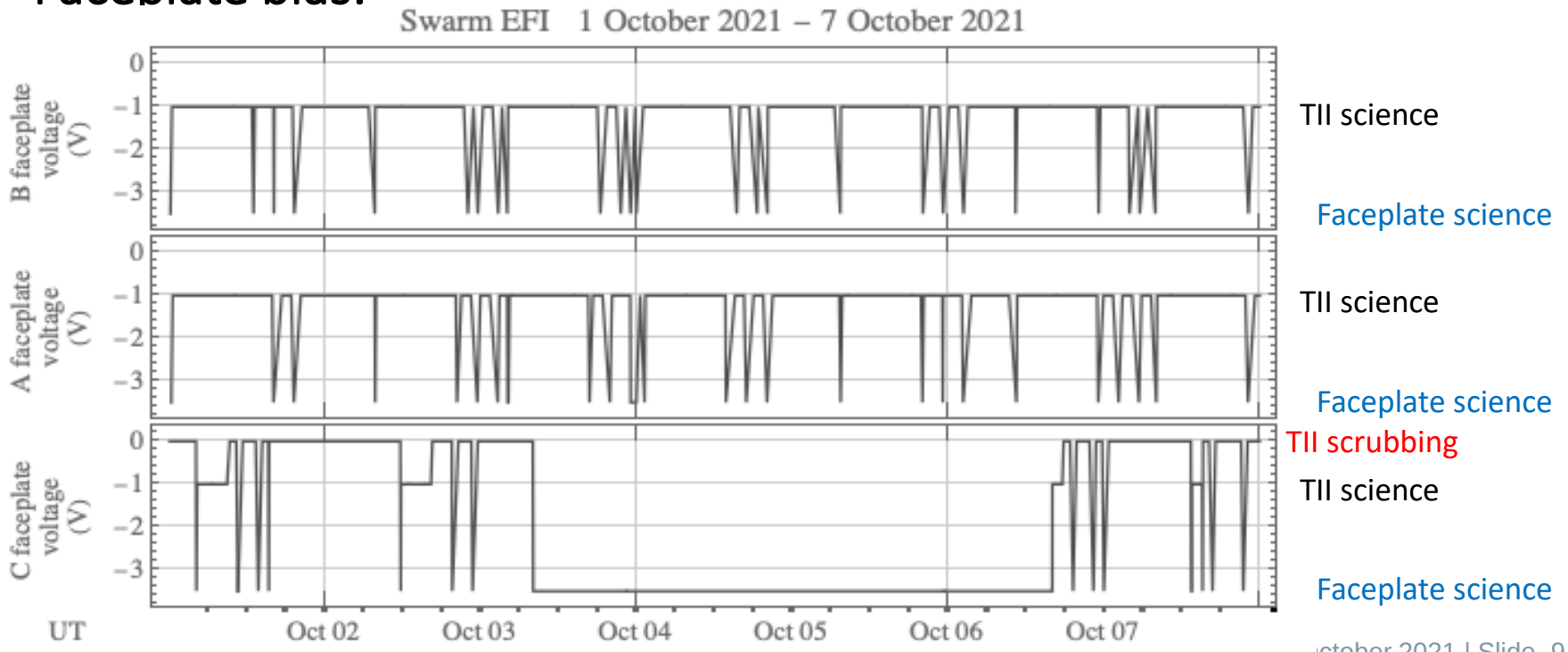
- The **application of the Lomidze [2018] correction on Swarm Te** reduces the original overestimation of Swarm measurements, but it is **more effective on Millstone Hill than on Jicamarca ISR**
- The accuracy of Swarm T_e data would take advantage from the **inclusion of the latitudinal and diurnal dependence of the calibration procedure**.
- Moreover, to better characterize the high T_e values, the **inclusion of data recorded by high-latitude ISRs in the Lomidze dataset** is advisable.

Swarm EFI TII instrument status and data quality

Presented by
Johnathan Burchill

- Science operations continue at reduced orbits per day (8 for Sw-A, Sw-B; 3 for Sw-C)
- Imaging anomaly investigation is ongoing
- **Seeking discussion and recommendation on science trade-off: faceplate current vs. cross-track ion drift from TII**
- Seeking recommendation for twice-per-year TII calibration manoeuvres (1/4 kg fuel / year / satellite)

Faceplate bias:



measurements from FP are scientifically relevant:

It is needed to plan a good strategy for the FP science acquisition in alternation to TII scientific mode

Recommendations

- Endorsement from DQ Community to transfer in operations the new baseline.
- Need of more cross-calibration **for *Ni and Ne.***
- Need to consider further comparison on Ni data from LP and FP
  - Suggestion to derive a **proxy for along track ion velocity** from the electron density provided by the LP
- Need to define a new quality flag for ***Te* spikes.**
- **Open discussion** on how to operate between **TII acquisition vs Faceplate science**
  - suggestion to stop science acquisition on Sw-C and use it only for FP measurements, so to have **TII regime on swA** and **FP regime on swC** ;
  - Suggestion to considering on demand (OPF) FP science acquisition mode ;
- Open discussion on **further Slew manoeuvres for TII calibrations** (interval TBD)
- Implementation of a **Fast production chain**

Session 5

Swarm-based L2 data products and services

13th October 2021

Summary of Session #5
(Swarm-based) L2 data products and services

- Erwan Thebault: A Spherical Harmonic model of Earth's lithospheric magnetic field up to degree 1050
- Alexander Grayver: A new approach of estimating electromagnetic induction transfer functions from satellite and ground data
- Patrick Alken: Updates to the equatorial electrojet and electric field product
- Louis Chauvet: Swarm Whistler L2 data
- Arnaud Chulliat: Extended climatological model of non-polar geomagnetic daily variations
- George Balasis: Swarm ULF wave indices using Convolutional Neural Networks
- Yaqi Jin: Validating electron density fluctuations at mid and low latitudes using GPS TEC data
- Ivan Pakhotin: The Swarm Langmuir Probe Ion Drift and Effective Mass: Validation Status
- Kevin Styp-Rekowski: Calibration of GRACE-FO and GOCE platform magnetometers using machine learning
- Lucas Schreiter: Topside Ionosphere Radio Observations (TIRO) from CHAMP, GRACE and GRACE-FO
- Martin Pačes: VirES for Swarm - evolution of the VirES and VRE services

Lithospheric magnetic field and mantle conductivity
large-scale ionospheric currents
small-scale ionospheric/magnetospheric currents and plasma irregularities
other

Summary of Session #5
(Swarm-based) **L2 data products and services**

- Erwan Thebault: A Spherical Harmonic model of Earth's lithospheric magnetic field up to degree 1050
- Alexander Grayver: A new approach of estimating electromagnetic induction transfer functions from satellite and ground data
- Patrick Alken: Updates to the equatorial electrojet and electric field product
- Louis Chauvet: Swarm Whistler L2 data
- Arnaud Chulliat: Extended climatological model of non-polar geomagnetic daily variations
- George Balasis: Swarm ULF wave indices using Convolutional Neural Networks
- Yaqi Jin: Validating electron density fluctuations at mid and low latitudes using GPS TEC data
- Ivan Pakhotin: The Swarm Langmuir Probe Ion Drift and Effective Mass: Validation Status
- Kevin Styp-Rekowski: Calibration of GRACE-FO and GOCE platform magnetometers using machine learning
- Lucas Schreiter: Topside Ionosphere Radio Observations (TIRO) from CHAMP, GRACE and GRACE-FO
- Martin Pačes: VirES for Swarm - evolution of the VirES and VRE services

Despite session title: most presentations combine **Swarm and other data sources**
Overlap with session #7 (Science Projects) -> merging to be considered for future QWG?

Increasing interest in "space science" with potential "space weather applications"

Posters – most of them concern "Level-2 type data"

1 Swarm PDGS Status & Evolution Antonio de la Fuente
2 Swarm data products delivered by GFZ to the ESA's Payload Data Ground Segment (PDGS) Guram Kervalishvili
3 Core surface flow changes associated with the 2016 Pacific jerk deduced from GVO secular variation gradients Kathy Whaler
4 Swarm L2: Comprehensive Inversion using 7½ years of Swarm Data Lars Tøffner-Clausen
5 Sequential modelling of the core magnetic field and associated flow Vincent Lesur*
6 Secular Variation Signals in Magnetic Field Gradient Tensor Elements derived from Swarm-based Geomagnetic Virtual Observatories Magnus Danel Hammer
7 Observatory quality magnetic data from ground and space Eija Tanskanen*
8 Estimating the properties of the magnetic lithosphere from satellite and aeromagnetic data Jörg Ebbing*
9 Inversion of the satellite-observed tidal magnetic fields in terms of three-dimensional upper-mantle electrical conductivity Jakub Velímský
10 Direct Sequential Simulation for spherical linear inverse problems Mikkel Otzen
11 Comparison of SWARM and GRACE time-variable gravity field at low degree spherical harmonics Hugo Lecomte
12 Equatorial Spread F-related electromagnetic energy flux Juan Rodriguez-Zuluaga
13 Dynamical complexity in Swarm time series using entropy analysis George Balasis
14 The effective ion mass estimated from Swarm Langmuir probe and faceplate data (SLIDEM project) Matthias Foerster
15 Different typical disturbances in Swarm LP and POD data detected by spectral analysis. Wojciech Jarmołowski
16 Quality Assessment and Features of the ePOP MGF 1 Hz Swarm L1b CDF lookalike product Martin Rother*
17 VirES and beyond: Data visualisation and a Python ecosystem for Swarm Ashley Smith*
18 Electron temperature across equatorial plasma density depletions Juan Rodriguez-Zuluaga
19 Time dependent Comsol simulations of the ASM/VFM magnetic field disturbance Gabriela Blaga*
20 Comparative Anomaly Detection for Swarm and CSES Data by Deep Learning-based Data Analytics Yaxin Bi
21 Combination of Swarm and COSMIC-2 ionospheric observations for plasma irregularities specification. Iurii Cherniak
22 Use of Swarm ionospheric products for COSMIC-2 Calibration/Validation campaign Irina Zakharenkova
23 First results from the Swarm DISC TOLEOS project: GRACE and GRACE-FO accelerometer data quality and radiation pressure modelling Christian Siemes*
24 The multi observations around strong Yutian Earthquakes in China during 2008-2020 Xuemin Zhang*
25 Altitude distribution of equatorial ionospheric irregularities sampled from an elliptical low-earth orbit Ali Mohandesi*

Recommendations, Session #5
(Swarm-based) L2 data products and services

Fast-track Swarm data provision

- Process and distribute "Fast-track" L1b data (magnetics, plasma, GPS …)
  Latency as short as possible (< 3 hrs ?), accept "data gaps"
- Process and distribute "Fast-track" L2 data (where it makes sense)

- More long-term: Investigate possibility of more frequent data downlink
  ideally using stations in N and S hemisphere to achieve data latency of shorter than ½ hour, although Northern hemisphere probably more interesting for European Space Weather applications

Recommendations, Session #5
(Swarm-based) L2 data products and services

Data sources other than Swarm

- "Navigational magnetometer" data and GPS data from "non-Swarm satellites"
  - Small-satellite large constellations like Planet and Spire ?
  - "larger single satellites" like CryoSat-2, Sentinel and others ESA-satellites ?

- Data exchange arrangements (if not yet done)
  make "non-Swarm" data available to Swarm user community in "Swarm like data format"
  (e.g. MAG_L1b daily CDF files)
  data distribution e.g. through ViRES/VRE and swarm-diss ftp server
  - Existing: CSES
  - Forthcoming: MacauSat, Daedalus, …

Recommendations, Session #5
(Swarm-based) L2 data products and services

Swarm and beyond

Swarm is the backbone of "Geomagnetism and Geospace Satellite Fleet" …
… synergy with other existing and future satellite missions

Session 6

Future missions

13th October 2021

Summary and Recommendations session 6 - Future Missions

Roger Haagmans & Ilias Daras

14/10/2021

Summary – Session 6

Daedalus: a proposed mission for the in-situ exploration of the lower thermosphere-ionosphere. Status update and results from the Daedalus Mission Simulator.

Theodoros Sarris

- Daedalus Phase 0 as ESA‘s 10th Earth Explorer mission successfully completed
- Daedalus was selected based on scientific merit, to proceed to Phase-A, but was considered to require further maturity in terms of programmatic aspects (Feb. 2021).
- It currently awaits ESA’s recommendation on the way forward, with international participation
- Daedalus will be able to provide, for the first time, all geophysical observables needed for the unambiguous quantification of key processes in the LTI, and enable addressing processes related to LTI energetics, dynamics and energetic precipitating particle effects.
- These processes will be quantified in-situ, with statistically representative sampling over the mission lifetime.
- Time window of implementation includes a probability to fly with Swarm, would be a much desired scenario that is also being analysed.

Summary – Session 6

Inferring ionospheric vertical profiles from Daedalus-like measurements and complementarity with Swarm

Octav Marghitu

- Reconstruction of Joule Heating profiles (height-integrated vs height-resolved)
- Systematic reconstruction of vertical profiles (electron density and conductivity) provides a sound basis for reconstruction of higher order quantities, like currents and Joule heating
- Complementarity with Swarm:
    - Height-integrated (magnetospheric) vs. height-resolved (I-T) perspective.
    - Daedalus based vertical profiles can be height-integrated and used to constrain/calibrate Swarm estimates
    - Swarm data can be used to provide upper continuation and to constrain the height-integrated TEC based on Daedalus

Summary – Session 6

Progress of CSES-02 development and the concept proposal of CSES-03 Constellation

Xuhui Shen, Zeren Droma

- CSES-01 launched on the 2nd of February 2018. Current status: Good health, Excellent performance with some problems in the Plasma Analyzer Package (PAP) and the Tri-Band Beacon (TBB).
- CSES-02 (in preparation – Nov 2022): Agreement signed between China and Italy on March 23rd 2019 with focus to continuously operate CS for 11+ years. Orbit designed to provide global coverage when complementing CSES-01 and cross-connect with MACAU-01 satellite.
- CSES-03 shall complement the CSES constellation with the objective to increase resolution and precision, monitor natural hazards and provide early warning and advance the research on multi-sphere interaction and coupling. Pre-research and developing project is on the works.

Summary – Session 6

MagQuest Phase 4: Tech Demos on Three Cubesats

Mike Paniccia

- MagQuest Phase 4b (2024-2025) - Magnetometer demonstration phase, with an independent performance assessment by NASA Goddard Space Flight Center
- MagQuest Phase 4c (~2026-2027) - Launch of all cubesats with launch readiness assessed by NOAA on data quality
- Beyond: A potential 20 year procurement for magnetic data.
- TBD if the data will be freely available to the public, though NGA hopes that will be the case.

Summary & Recommendations – Session 6

Latest news about the NanoMagSat project

Gauthier Hulot

- Programmatic status:
  - Nov 2020 – ACEO evaluated with a very good grade the science value of the mission but ESA recommended further maturation of key technologies.
  - Feb 2021 - ESA PB-EO approved to proceed with the Risk Retirement Activities (RRA). Consortium went in dialogue with ESA.
  - Oct 2021 – ITT issued by ESA
- More discussions in the dedicated NanoMagSat session on Friday p.m and Saturday a.m.
- Intention to (re-)submit NanoMagsat to the next Scout call of ESA in 2022 (TBC)

Summary & Recommendations – Session 6

A high-precision and highly-elliptical-orbit geomagnetic constellation

Keke Zhang

- A staggered approach is proposed for 4 consecutive launches.
- The first two satellites: launch in a staggered approach in low-inclined orbit (app. 40 degrees)
- The next two satellites: launch in a staggered approach in near-polar elliptic orbits (200-5000km)

- Objectives aligned with Swarm and potential to offer complementary low-inclined data with faster local time sampling.

Recommendations

To the user community:

1. It would be beneficial to **align orbits of future satellites or constellations** (large & small) with Swarm. Depending on the launch date with Swarm A,B & C or Swarm B.

2. Aim at **defining cross-mission objectives** which may not be possible by one or the other mission or enhance existing objectives. This strengthens the position of all individual missions and implicitly provides objectives for future extension of Swarm.

3. Start **generating and elaborating** post-Swarm **mission ideas** which can be submitted to the **future Earth Explorer 12** call (2023 TBC). Potentially use the principle of designed and controlled constellations recently developed for time variable gravity field missions.

To ESA and the user community:

1. Ensure that **all data of complementary missions** (e.g. Daedalus, Swarm, Macao, CSES, NanoMagsat, MagQuest) provide **data open and free to the science community for validation and science**

2. Explore the possibility for a **workshop to align existing and future missions.**

Session 7a

Science projects and applications

14th October 2021

Sub-session 7a

Reporting by Kathy Whaler

Sub-session contents

11 talks on a variety of topics using magnetic field and LP data

- Related to the core field and dynamics
- Field-aligned currents, Joule heating, …
- New ionospheric and plasmapause indices
- Equatorial electrojet
- Loss-of-lock for GPS satellites

Themes

- Several talks showcased results from ESA-funded projects
- Many different approaches to probe similar physics, often taking advantage of complementary datasets (especially from other satellites)
- Identification and separation of sources is getting better
- New results derive from good coverage Swarm provides – e.g. spatially and local times, conjunctions

Future prospects

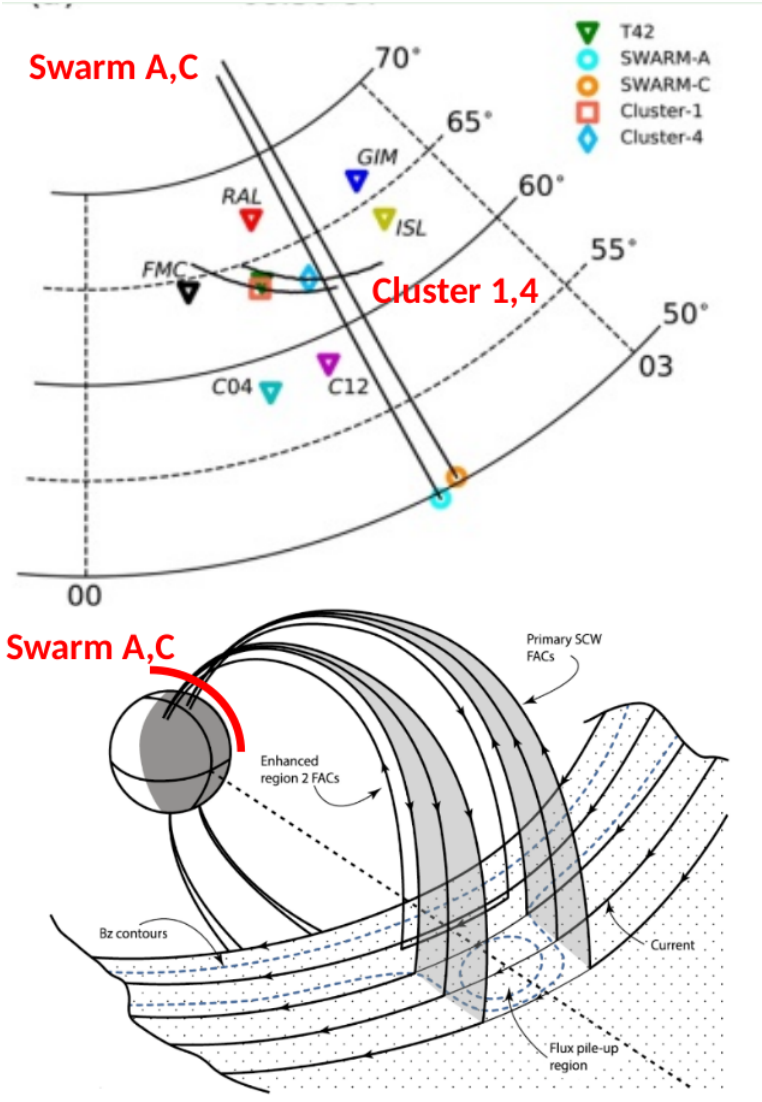
- Additional synergies will come from bringing individual projects studying similar phenomena together – the total will be greater than the sum of the parts
- We are getting new and/or clearer ‘windows’ on physical processes
- We are definitely seeing the benefit of long time series – starting to move towards climatology

Session 7b

Science projects and applications

14th October 2021

Session #7, Science projects and applications



M. Dunlop, shows a GIC that can be traced to a magnetosphere event (BBF)

- presentations from a broad range of subjects:
  1. activity proxies/indices
  2. energetic particles/violent events
  3. small and large scale structures/dynamics
- involving numerous data sets and missions:
  1. Swarm inc. Swarm-E
  2. magnetosphere/heliosphere missions (Cluster, MMS, . . .)
  3. groundbased magnetic data, lightning networks. . .

Discussion and Recommendation

- "Strategic"
  - think "System Science"
  - e.g. solar cycle influence in the heliosphere,. . . ,applications such power grids, navigation/positioning systems;
  - how: "Swarm ideas workshop" and/or continued discussion on Brella
- "Practical"
  - LP "spike trains" need to be flagged (there has been progress under the meeting)
  - can L2 products include more Swarm-E?, e.g. TEC for E GAP, IPIR based on E plasma current?

Session 8

Swarm - CSES synergies

15th October 2021

Session 8: Swarm – CSES synergies

- Zeren Zhima, Cross-calibration on the electromagnetic field detection payloads onboard CSES.
- Yanyan Yang, In-flight calibration of CSES HPM data
- Rui Yan, The regular interferences recorded by Langmuir probe on-board low Earth polar orbit satellite CSES
- Yaxin Bi, Predicting Swarm Observations and Detecting Anomalies within the Observations by Deep Learning Approaches
- Dedalo Marchetti, Comparison of Swarm and CSES to study ionospheric disturbances before or during the occurrence of medium / large earthquakes
- Xiaochen Gou, Ionospheric Pc1 waves during a storm recovery phase observed by the China Seismo-Electromagnetic Satellite
- Qiao Wang, The effects on lightning whistlers analysis due to discontinuities in SCM waveform data

-> Mainly Chinese presentations on CSES

-> Examples of how the **CSES team could take advantage of expertise from the Swarm community**

Session 8: Swarm – CSES synergies Recommendations

- **The collaboration has mainly focussed on improving the quality of the CSES data**

-> To be continued

- **Making the CSES data more easily accessible also is a priority**, so Swarm partners can more readily work on **science exploitation**, in particular **in conjunction with Swarm data**

-> through "Swarm-like" daily CDF files. Presently data for almost trhee years are available (mid 2018 to mid 2021). It would be great to make these data also available to the whole Swarm science community, e.g. through the ViRES/VRE platform.

- **Coordination of special operations** (e.g. Burst mode sessions on Swarm) also **recommended**, but this again requires sharing data
- **Resume ISSI type of joint work** on specific issues and **scientific topics**, to further encourage collaboration (both ways)
- **Organize a dedicated Swarm/CSES meeting next year** (on JOINT use of data)
- Good **coordination between Swarm and CSES should be extended to follow-on CSES-2, CSES-3 (set up agreements for this)**