MIST reunited

Article

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Autumn MIST 2022 article for A&G

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The first in-person Autumn MIST to be held since the start of the COVID-19 pandemic was held in the Geological Society buildings on Friday 18th November 2022 as a very successful hybrid meeting with 89 people physically attending and 24 online. The meeting was split into 3 oral sessions: planetary, solar and Earth based presentations with 2 poster sessions to accommodate the very large number of abstract submissions to this thriving meeting.

Investigations at the planets

The first session of the day collected a selection of planetary based presentations together. **Mark Lester** from the University of Leicester began the day by presenting Mars radar data from the MARSIS instrument on the MAVEN spacecraft during Solar energetic particle events. Using radar blackouts from MARSIS in the AIS mode (when it is a topside ionospheric sounder which also receives reflections from the surface) in conjunction with the MAVEN SEP particle instrument, Mark demonstrated the presence of a highly variable ionisation layer in the low altitude atmosphere of Mars.

Katerina Stergiopoulou from the University of Leicester continued the session with an investigation of the induced magnetotail at Venus using data from 2 Solar Orbiter flybys of the planet. Taking electron density and magnetic field measurements from the spacecraft, Katerina compared these to hybrid simulations of Venus' magnetosphere using a model by Jarvinen and Kallio from Aalto University in Finland (Figure 1). The comparison found times when the observed magnetic field vector was rotated from the modelled vector and possible evidence from escaping plasma.

Charlotte Goertz from Northumbria University took us on a tour of the diamagnetic cavity that occurs within the plasma environment around comets. Charlotte showed how these cavities where the magnetic field strength is zero and no solar wind is observed rather surprisingly sometimes contain protons as shown by the Rosetta measurements of comet 67P/Churyumov-Gerasimenko. Having ruled out several other possibilities, Charlotte proposed that these protons can enter the cavity when the interplanetary magnetic field is parallel to the solar wind velocity.

To finish the planetary session, **Cristian Radulescu** from University College London presented findings on the distributions of pick-up ions at Saturn using Cassini data. These are ions that were recently neutral particles ejected by the moon Enceladus and have been "picked-up" by the fast moving plasma in Saturn's magnetosphere. The evolution of the velocity distribution of these ions is related to the production of ion cyclotron waves. Analysing data between 4 and 6

RS, Cristian found that the region of most intense ion cyclotron waves (centred on the equator) is co-located with the region of narrower ion pitch angle distributions and vice versa (FIgure 2).

Solar Wind studies

The second session was centred on Solar talks beginning with **Harriet Turner** from the University of Reading looking at the use of real time data in solar wind data assimilation. Noting the difference in the data between real time and the cleaned up science level data which appears some time later, Harriet showed that using the BRaVDA scheme (Burger Radius Variational Data Assimilation) with real time data did not significantly worsen forecasts of the Solar wind (Figure 3). Harriet also showed that a future mission pairing of both an L5 and L1 monitor would improve forecasts of solar wind speed.

Next up, **Naïs Fargette** from Imperial College London described his work on the clustering of reconnection exhausts in the Solar wind. Past observations have shown observations of many reconnection jets at 1 AU but very few at 0.1 AU. Using Solar Orbiter data, Naïs set up an automatic detection algorithm and found 163 jets in a span of 24 days at 0.7 AU. Upon analysing the time in between jets, there was evidence of jets clustering together in time with the jets typically of short duration and low shear (Figure 4).

Alina Bendt from the Centre for Fusion, Space and Astrophysics at the University of Warwick investigated the use of wavelet decomposition on Solar Orbiter data to investigate turbulence in the Solar wind. With non-gaussian probability distribution functions confirming turbulence Alina found the scaling component was close to 3/2 but not fully in the inertial range with fractal behaviour in the kinetic range and multi-fractal behaviour in the inertial range.

In the penultimate talk of the session **Abid Razavi** at the Mullard Space Science Laboratory presented studies of interplanetary shocks. Abid showed examples of flat top shock distributions, so named from their shape in phase space density versus energy, from Solar Orbiter data. The shape of the distributions has implications for the energy dissipation at a shock and these case studies are the start of a larger statistical investigation.

In the final talk of the Solar session, **Domenico Trotta** from Imperial College London presented analysis of particle acceleration at interplanetary shocks, focussing on upstream steep structures known as shocklets. A multi-spacecraft case study of a strong shock using observations from Solar Orbiter, Wind, THEMIS, DISCOVR and ACE shows the broad spatial extent of these phenomena upstream from the shock front.

Earth based science

The final session of the day hosted talks focused on the Earth-centric science performed by the MIST community. **Ciaran Beggan** from the British Geological Survey (BGS) started the session by providing a description of how the BGS are increasing the number of locations at which observations of the magnetic field are made in the United Kingdom. Three new sites are being added to the current network of four existing magnetometers to dramatically improve the spatial coverage available. These stations now return high quality magnetic variation data through the 4G network in near real time, and improve our ability to monitor space weather.

Next, **Harley Kelly** from Imperial College London discussed how current understanding of the Kelvin-Helmholtz instability is based on simplified and unrealistic assumptions, partly because of how hard they are to measure with spacecraft. Harley then showed how they are using GORGON MHD (MagnetoHydroDynamic) simulations to probe Kelvin-Helmholtz votices in global-scale 3D simulations. They locate the structures by searching for pressure minima, finding more Kelvin-Helmholtz structures on the magnetopause, where they form tubular structures, than in the magnetotail.

Nonetheless, a complex series of phenomena occur in the Earth's magnetotail. Some of these processes are linked to magnetospheric substorms: a global cycle of energy storage and release that can be monitored in different data sets, using a range of techniques. **Christian Lao** from University College London presented their work comparing and contrasting the different databases of substorms that identify substorms through distinct methods. None of these competing catalogues agreed entirely with another, yet the time differences between them (when they agreed) was equal to the shortest time tested - suggesting that the events are near-simultaneous when the same event was recorded.

Gemma Bower from the University of Leicester then presented their work investigating the formation and evolution of a type of auroral configuration known as "Horse Collar Aurora". This kind of auroral event was shown to occur during northward IMF (interplanetary magnetic field) conditions, with 11 case study events (out of 650) showing sufficient data to examine the auroral forms in more detail. In all cases the formation and motion of the aurora appeared to be governed by the sign of the IMF By component, as predicted by the Milan et al., [2020] model.

Following this, **Tom Daggitt** from the British Antarctic Survey (BAS) described their work exploring how the radiation belts - and charged particles therein - interact with the ever changing location of the magnetopause. During intervals where the magnetopause is compressed the radiation belts lose particles when and where they intersect. Tom showed how existing analytical models of the magnetic field can predict this process on a large scale, but fail to do so during short-lived events where the magnetopause is compressed to within geosynchronous orbit. Further, there is a strong dependence on the magnetic local time of the observations, with satellites in similar but offset orbits encountering very different flux profiles [Daggitt et al., 2022].

Gareth Dorrian from the University of Birmingham then moved the session down to the Earth's ionosphere, discussing a new way to monitor ionospheric disturbances using the LOFAR (LOw Frequency ARray) radio telescope. This pan-European telescope is designed for radio astronomy, but by monitoring natural, consistent radio sources Gareth used it to understand the changing ionosphere through which the received radio waves must travel. By monitoring different astrophysical sources they could map where ionospheric disturbances existed and how they moved, results that were consistent with maps derived independently using GPS observations (Figure 5).

The next talk returned us to the radiation belts: **Shannon Killey** from Northumbria University presented their work on using Machine Learning to diagnose the behaviour of relativistic electrons within the radiation belts. Shannon uses a series of advanced methods to group similar types of radiation belt observations, allowing them to isolate when and where certain conditions manifest (Figure 6). During the seven years of observations, five types of plasma conditions are found to dominate. One type, the “butterfly” shaped distribution is mainly seen at the edges of the belts, and is thought to represent regions where waves and particles are interacting, exchanging energy. Meanwhile during dynamic geomagnetic storms the type of conditions changes over time.

For the final talk of the session, **Ingrid Cnossen** from BAS brought us to the upper atmosphere of the Earth, discussing their work predicting the impact of climate change on the upper atmosphere and its consequences for space debris. Ingrid’s simulations run from the present day through to 2070 and include the effects of solar and geomagnetic variability, along with changing trace gas (e.g. CO_2) emissions. These simulations show a long term decrease in density of the upper atmosphere, with the knock on effect that space debris will last for longer before burning up in the atmosphere. This amounts to 15% more debris by 2070 and indicates that there will be more frequent catastrophic collisions.

[Use box presentation for the posters?]

Poster Presentations

In addition to the excellent oral presentations we had 37 posters split across two sessions.

Joel Baby Abraham	Mullard Space Science Laboratory	Radial Evolution and Energy Budget of Thermal and Suprathermal Electron Populations in the Slow Solar Wind from 0.13 to 0.5 AU : Parker Solar Probe observations.
Anasuya Aruliah	University College London	Are thermospheric models overestimating mass density?
Sarah Bentley	Northumbria University	Radial Diffusion Benchmarking: Initial Conditions
Shahbaz Chaudhry	University of Warwick	Global dynamic network response of Pc2 waves to the 2015 St Patrick’s day storm using SuperMAG and Intermagnet ground based magnetometers
Joseph	Imperial	Global Magnetospheric Modelling with Gorgon

Eggington	College London	
Omar El-Amiri	University of Warwick	PIC Simulations of Electromagnetic Ion Beam Instabilities in Earth’s Foreshock
Amy Fleetham	University of Leicester	AMPERE, GICs and the Electric Current of Geomagnetic Storms
Colin Forsyth	Mullard Space Science Laboratory	Potential observations from nanosatellites in ESA’s D3S programme
Laura Fryer	University of Southampton	Global magnetotail configurations of simulated pressure pulses during northward IMF conditions.
Imogen Gingell	University of Southampton	Simulations of the decay of reconnected structures downstream of Earth's bow shock
Sarah Glauert	British Antarctic Survey	Theoretical loss timescales and pitch angle distributions for the radiation belts
Adrian Grocott	Lancaster University	SuperDARN observations of the two component model of ionospheric convection
Rosie Hodnett	University of Leicester	Harmonic Frequency Separation of Ionospheric Alfvén Resonances Observed at Eskdalemuir
Lauren James	University of Reading	Sensitivity of Model Estimates of CME Propagation and Arrival Time to Inner Boundary Conditions when Constrained by Spacecraft Data.
Simon Joyce	University of Leicester	Update on the Mars Express Active Ionospheric Sounder data processing
Andrew Kavanagh	British Antarctic Survey	DRivers and Impacts of Ionospheric Variability with EISCAT_3D (DRIIVE)
Adrian LaMoury	Imperial College London	Magnetopause reconnection and dynamics following the impact of magnetosheath jets
Andrea	Queen Mary,	The interplay between magnetic switchbacks and solar wind

Larosa	University of London	turbulence in the inner heliosphere
Harry Lewis	Imperial College London	Generalised Ohm's Law in the Magnetosheath: Relative Contributions to Turbulent Electric Fields as Modified by Plasma Conditions
Subir Mandal	British Antarctic Survey	Understanding the Gravity Wave Activity in the Scandinavian Mesospheric Region as part of the MesoS2d Project
Jack McIntyre	Queen Mary, University of London	Parameters underlying the evolution of the magnetic field spectral index in the solar wind
Tracy Moffat-Griffin	British Antarctic Survey	MesoS2D:Mesospheric sub-seasonal to decadal predictability
Michaela Mooney	University of Leicester	Evaluating Auroral Forecasts Against Satellite Observations
James Plank	University of Southampto n	Measures of Correlation Length at Quasi-Parallel and Quasi Perpendicular Shocks
Catherin e Regan	Mullard Space Science Laboratory	Investigating the 2007 Global Dust Storm at Mars with Mars Express
Jade Reidy	British Antarctic Survey	Preliminary analysis of low altitude electron density measurements from EISCAT
Sam Rennie	University of Leicester	SuperDARN Observations of High-m ULF Waves
Jasmine Sandhu	Northumbria University	Exploring the complex response of ULF waves to plasmaspheric plumes
Md Goribullh a Shah	Queen Mary, University of London	Multiband Whistler Mode Waves in the Earth’s Magnetosphere: MMS Observations and Two-Fluid Plasma Simulations
Julia Stawarz	Imperial College London	The Evolution of Intermittency in the Solar wind During a Radial Alignment Between Parker Solar Probe and Solar Orbiter

Gabriel Suen	Mullard Space Science Laboratory	Solar Orbiter Observations of Switchback Dissipation Through Magnetic Reconnection
Maria-Theresia Walach	Lancaster University	Dusk-Dawn Asymmetries in SuperDARN Convection Maps
Xueyi Wang	University of Warwick	Wavelet analysis determination of scaling exponents and ranges in the magnetohydrodynamic range of solar wind turbulence seen by Parker Solar Probe
James Waters	University of Southampton	A Perspective on Substorm Dynamics Using 10 Years of Auroral Kilometric Radiation Observations from Wind
Cara L. Waters	Imperial College London	Calibration and Attitude Determination of the Inboard Magnetometer on the RadCube CubeSat
Emma Woodfield	British Antarctic Survey	The effect of Z-mode waves on the electron radiation belt at Jupiter.
Sophia Zomerdijk-Russell	Imperial College London	Assessing how BepiColombo will use Solar Wind Variability to Probe Mercury's Interior

MIST council would like to thank the Geological Society for hosting Autumn MIST 2022 and for the continued support for MIST from the Royal Astronomical Society. Furthermore, we thank all attendees and presenters for contributing to an engaging and enjoyable meeting.

References

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Milan, S. E., *et al.* 2020, *Journal of Geophysical Research: Space Physics*, *125*(10), e2020JA028567, doi: 10.1029/2020JA028567

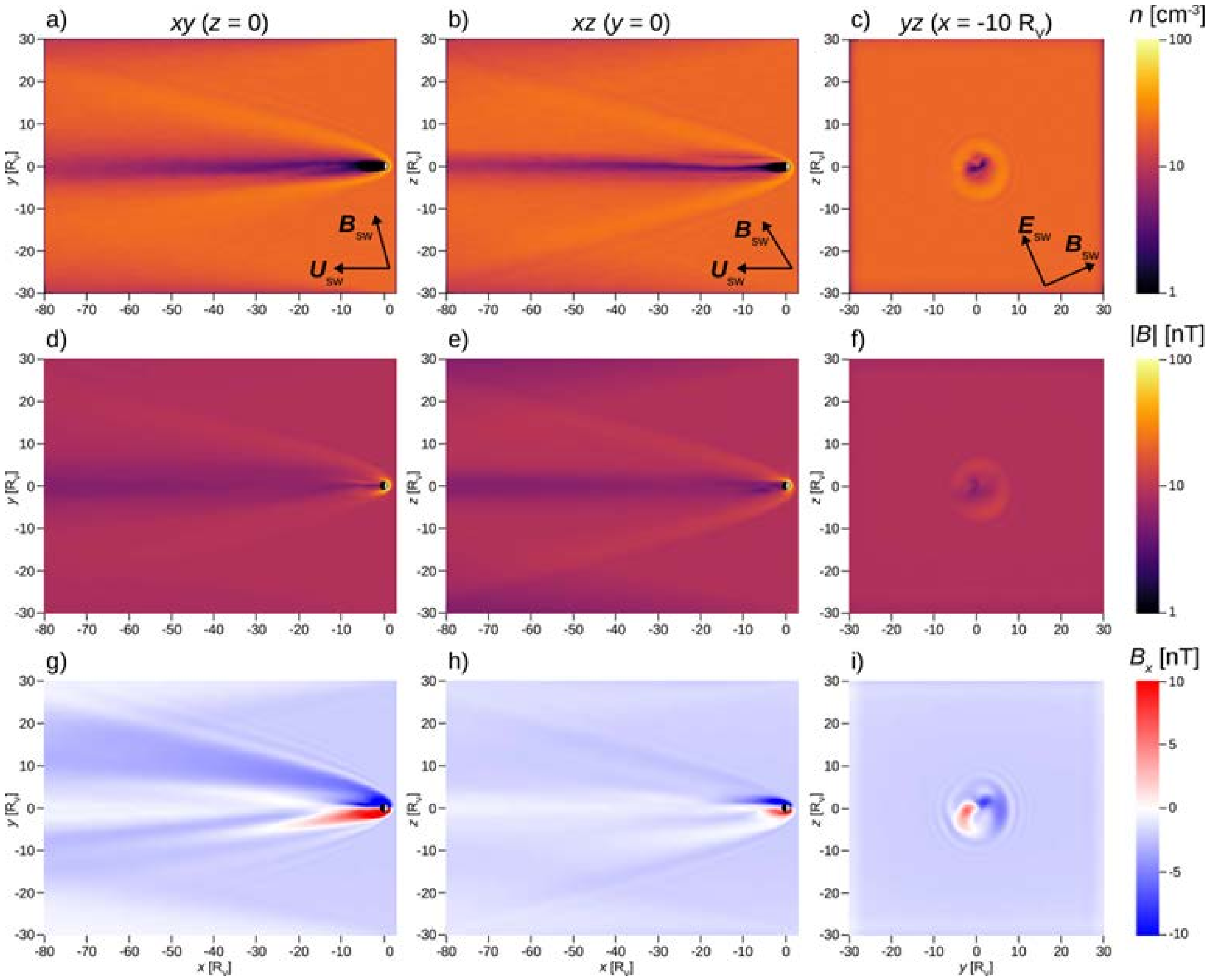

Figure 1. Simulation results of the solar wind-Venus interaction from the global hybrid simulation RHybrid developed by Jarvinen and Sandroos at theFinnish Meteorological Institute (FMI). Solar wind density in XY, XZ and YZ VSO planes in (a)–(c), magnetic field magnitude in (d)–(f) and the X component of the magnetic field, *Bx*, in (g)–(i). (Reproduced from Figure 4 of Stergiopoulou *et al.*, 2023, JGR, 128, 2, DOI: 10.1029/2022JA031023)

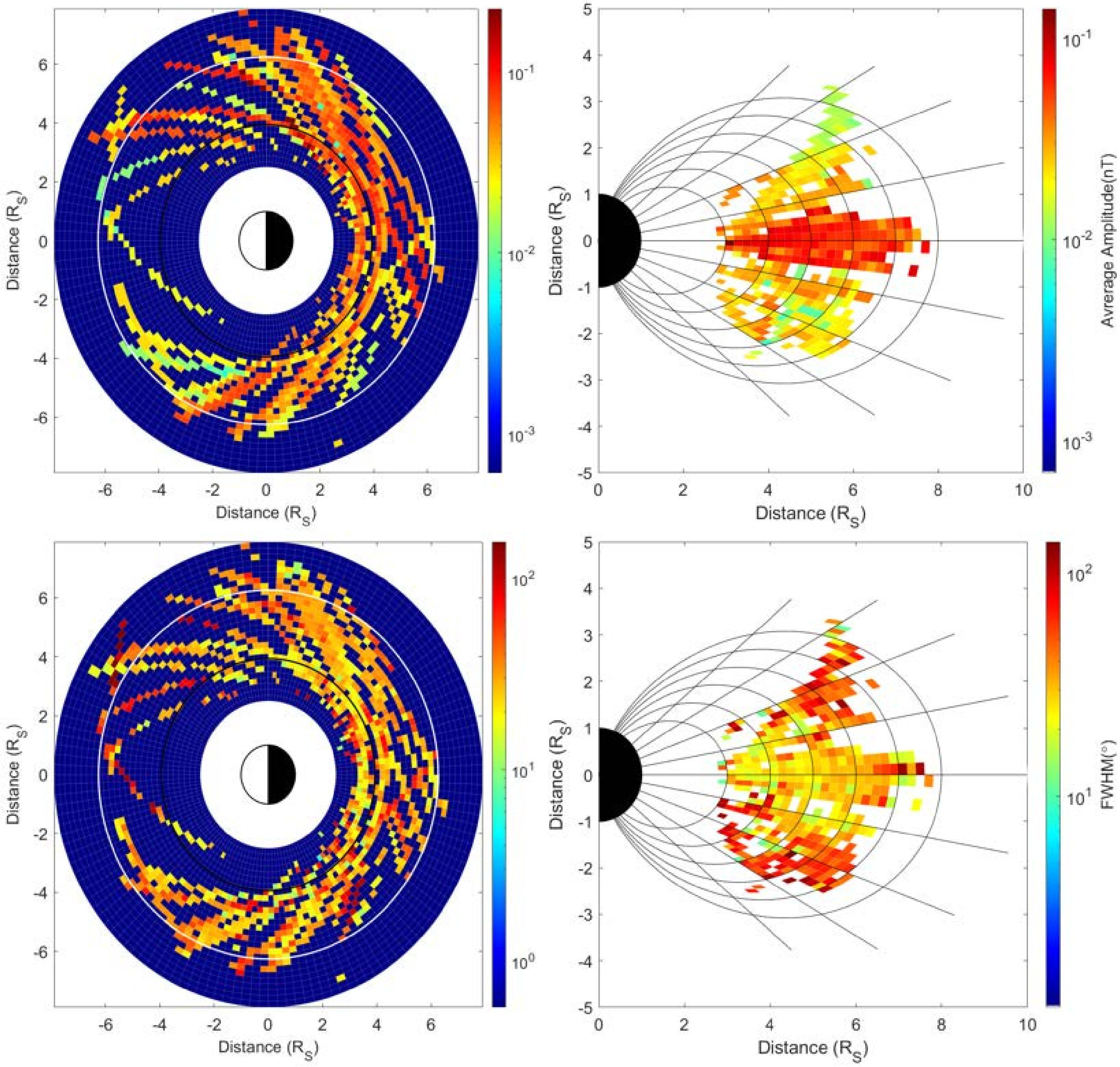

Figure 2. Cassini observations of ion cyclotron waves at Saturn showing the average amplitude (top row) and the full width at half maximum of the water group pick-up ion pitch angle distributions (bottom row).

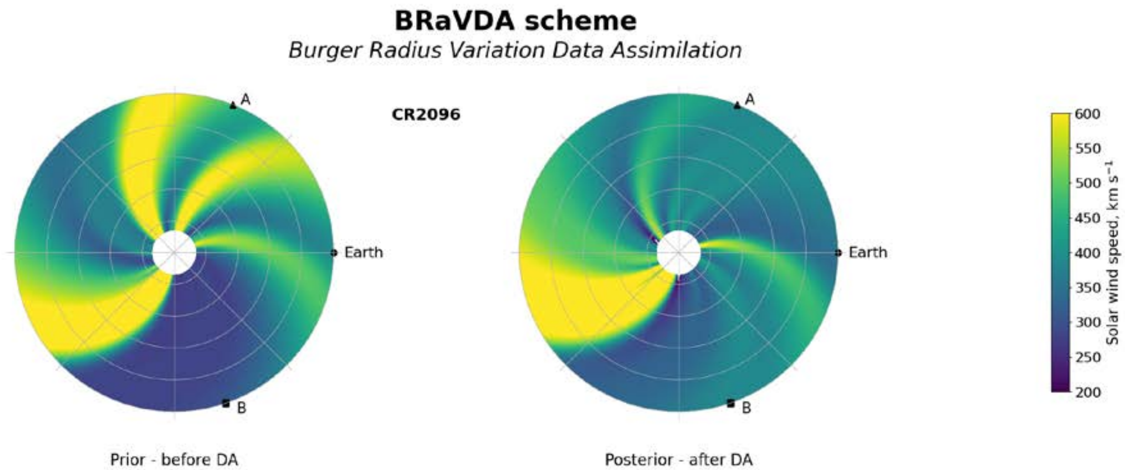

Figure 3. Solar wind solution from the BRaVDA model using the simplified solar wind model HUX, initialized on 22/04/2010 for Carrington Rotation 2096 (22/04/2010 to 19/05/2010). The prior state (left) is that before the in situ data assimilation has taken place and the posterior state (right) is after the data assimilation. Indicated on both panels is the location of STEREO-A (A), Earth and STEREO-B (B) on 22/04/2010. (Reproduced from Figure 1 of Turner *et al.* 2022, Space Weather, 20, 8, DOI: 10.1029/2022SW003109)

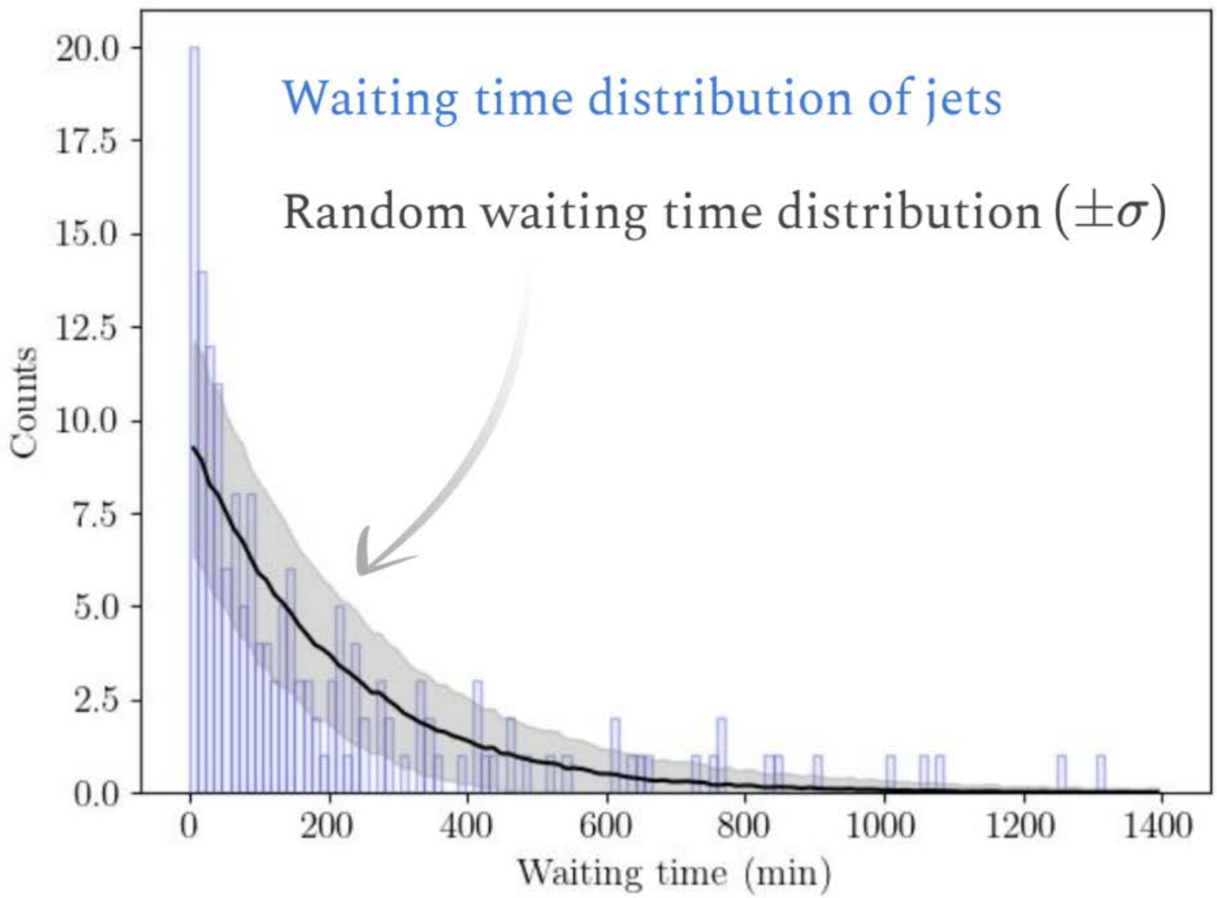

Figure 4. The waiting time distribution of reconnection exhaust jets in the solar wind.

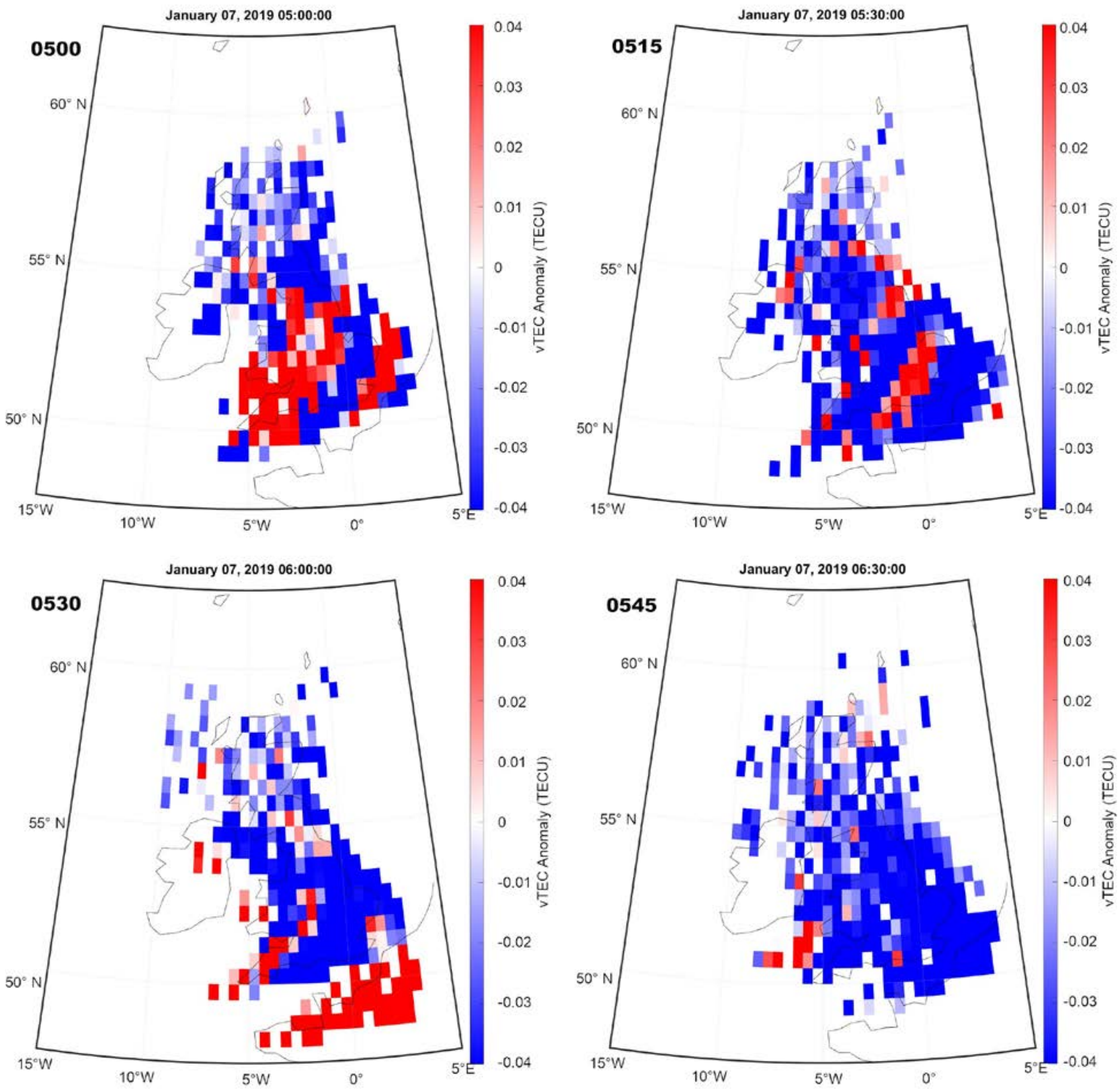

Figure 5.Global Navigation Satellite System Total Electron Content anomaly data, averaged to 30-min (adapted from Figure 10 of Dorrian, G. *et al.*, 2023, *Space Weather*, 21, e2022SW003198. DOI: 10.1029/2022SW003198 with credit to David Themens, University of Birmingham).

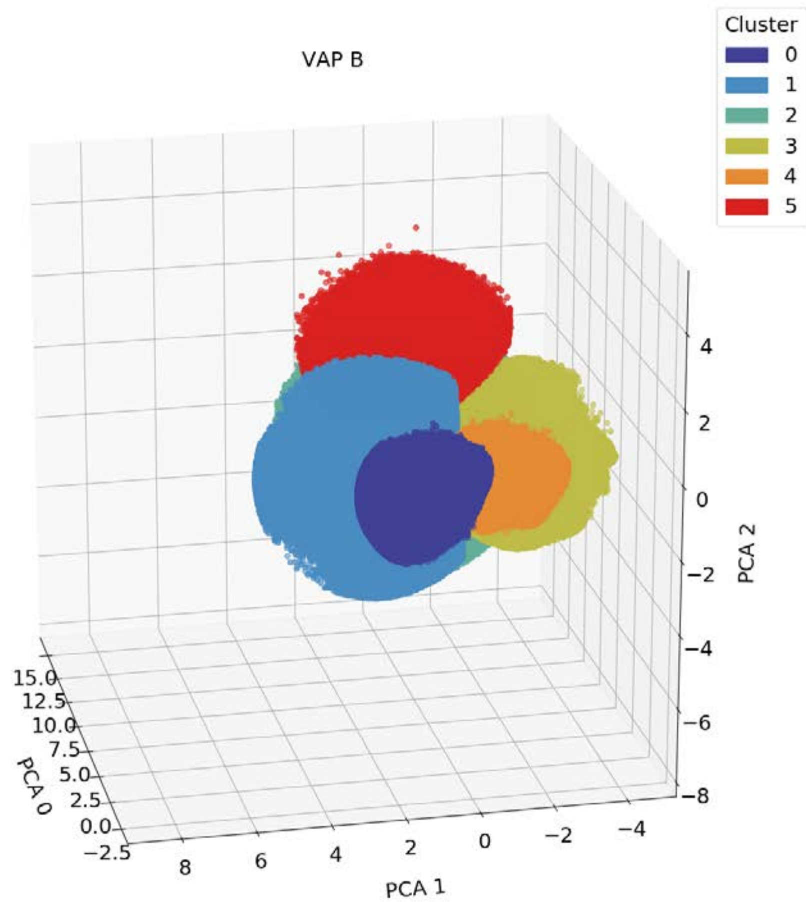

Figure 6. Seven years of Van Allen probe REPT data has been processed using an autoencoder neural network followed by principal component analysis to reduce the dimensionality of the data. This figure shows the clusters of similar plasma conditions that emerge from using K-means clustering on the reduced dimension data.