Note from the author of this White Paper:
"I would be very happy to receive comments and suggestions for improvement." July 4, 2012.

Opportunities for Cooperation:

THEMIS and RBSP

Attractive New Figures From A.U.

Dated February 17, 2012

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Executive Summary. This document outlines potential joint scientific studies involving the THEMIS and RBSP missions as a function of mission phase from the commissioning of RBSP in August 2012 through the end of its prime mission in the summer of 2014. It describes consensus recommendations for interspacecraft separation, fast survey and burst mode strategies for THEMIS that will enable the two missions to achieve and exceed their common objectives.

Introduction

Although both stand alone missions, RBSP and THEMIS have much to offer each other. Ring current and radiation belt studies are central to each mission. Working together, the two missions can identify particle source populations, define the extent and significance of energization processes, and quantify loss mechanisms. With appropriate planning both missions can ensure that they achieve and exceed their stated objectives, without the need to rely upon fortuitous spacecraft conjunctions and operation modes. This document describes mutually beneficial joint research activities as a function of mission phase, with recommendations for THEMIS spacecraft operations.

The primary science objective of NASA's Radiation Belt Storm Probe (RBSP) mission is to provide understanding, ideally to the point of predictability, of how populations of relativistic electrons and penetrating ions in space are produced or change in response to variable inputs of energy from the Sun. The three overarching scientific questions that define the mission are to determine: (1) the physical processes that produce radiation belt enhancement events, (2) the dominant mechanisms for relativistic electron loss, and (3) how the ring current and other geomagnetic processes affect radiation belt behavior.

The two spacecraft that comprise the RBSP mission will be launched no earlier than August 15, 2012 into low-inclination (±10° from the ecliptic) lapping equatorial orbits with, periods of 9 hours, perigee altitudes of ~600 km and apogees of 5.8 R_E geocentric. Initial apogees will be near 0900 local time, and the orbital precession rate is ~200°/year. Following a two-month commissioning period, the spacecraft will begin scientific operations near the dawn meridian, with their orbits precessing once around the Earth during the course of the two-year primary mission. The RBSP spacecraft will lap each other 4 times per year, i.e. twice per quadrant of local time over the entire mission.

The identically-equipped RBSP spacecraft will carry the comprehensive instrumentation packages required to achieve mission objectives, including: ions from 20 eV to 75 MeV (with composition from 20 eV to 300 keV), electrons from 20 eV to > 10 MeV, 3-D DC electric (to 10 Hz) and magnetic (to 30 Hz) fields, and 3-D wave electric and magnetic fields from 10 Hz to 12 kHz (1-D E to 400 kHz). In addition, and outside mission requirements, they will carry Relativistic Proton Spectometers provided by the National Reconnaissance Office and Aerospace Corporation which are capable of measuring ions with energies from 50 MeV to 2 GeV.

NASA's THEMIS and ARTEMIS missions have the capability to provide RBSP with important information concerning both solar wind and magnetospheric conditions. From 2010 to 2011, the outermost two of the original five THEMIS spacecraft were detached and moved to lunar distances, where they have been rechristened ARTEMIS and can frequently serve as solar wind monitors for the RBSP mission. The innermost three spacecraft will remain in nearly-identical orbits around Earth with geocentric apogees of 11.7 R_E, orbital periods of 1 day, inclinations ranging from 1 to 8°, and precession rates of

~330°/year. At the time of writing (August 2011), all instruments on all THEMIS/ARTEMIS spacecraft are fully functional. These instruments provide ion and electron plasma and energetic particle distribution functions and moments (but not composition) from 30 eV to 6 MeV. Detailed electric and magnetic field waveform and spectral measurements extend from DC to 4 kHz (8 kHz for the AC E-field data), with a single integrated spectral density measurement of the electric field covering the range 100-400 kHz.

As summarized in Table 1, the THEMIS spacecraft operate in four modes: slow survey, fast, survey, particle burst mode, and wave burst mode. Fast survey mode intervals are set in advance, while particle and wave burst mode intervals can be set or triggered during fast survey intervals.

Table 1
THEMIS Instruments and Modes

	Instrument	Slow	Fast	Particle Burst	Wave Burst
FGM	Fluxgate Magnetometer	FIT	0.25s		0.008s
SCM	SearchCoil Magnetometer	FBK	FWS		FCW
EFI	Electric Field Instrument	FIT/ FBK	0.12s WF FWS		FCW
ESA	Electrostatic Analyzer	MOM	RDF	Full Cadence FDF	
SST	Solid State Telescope	Spectra	RDF IFDF	Full Cadence FDF	

FIT: 3s spin period fit, MOM: 3s onboard moments, RDF: 3s reduced angular particle distribution function, FDF: Full angular particle distribution function, 3s IFDF ion full distribution function, FCW: Full cadence waveforms, FBK: 4s filterbank wave spectra, FWS: Fourier wave spectra, WF: waveforms

When the commissioning of RBSP is complete in mid to late October 2012, the apogees of the three remaining THEMIS spacecraft will be near 1800-1900 LT. From these locations, THEMIS can routinely provide information concerning processes occurring in the duskside magnetosphere, for example the Kelvin-Helmholtz instability at the magnetopause, ions injected by substorms, and EMIC wave activity while RBSP monitors corresponding processes in the dawnside magnetosphere, for example the Kelvin-Helmholtz instability, electron injections, and higher frequency waves such as upper and lower band chorus or magnetosonic waves. At later stages during the RBSP mission, the THEMIS spacecraft will be able to provide information concerning source populations in the magnetotail plasma sheet, the steady and impulsive convection that energize particles to ring current and radiation belt energies, external drivers (e.g. interplanetary shocks and upstream pressure pulses transmitted through the magnetosheath and reconnection at the magnetopause), the spatial and temporal extent of ULF and VLF wave fields that energize particles, loss processes (e.g. magnetopause shadowing and wave activity), and the configuration of the geomagnetic electric and magnetic fields.

In exchange, RBSP can complement THEMIS by providing information on ion composition. This information is essential not only when cross-calibrating the instruments, but also in studies of ring current waves and instabilities, as well as energization mechanisms during substorm injections.

Many of the goals of both missions require intercomparisons of the particle phase space densities. In addition to helping determine dawn/dusk asymmetries, tracking the evolution of the ring current and radiation belts, and determining the plasma pressure gradients that drive field-aligned currents, such intercomparisons can aid in identifying, or excluding, possible source, transport, and loss mechanisms. Simultaneous multipoint observations are also needed for data assimilation or reanalysis studies designed to reconstruct radial phase space density profiles. While there are many ways to generate specific radial phase space density profiles and phenomena such as drift orbit bifurcation may preclude the use of such profiles to discriminate amongst various mechanisms, these phenomena are in turn equally worthy of study. Success in achieving the mutual objectives of the RBSP and THEMIS missions will require careful intercalibration of the particle measurements from each mission.

In addition to describing the enhanced scientific return made possible via coordinated studies of RBSP and THEMIS observations, the purpose of this white paper is to specify, as a function of mission phase, three THEMIS parameters that can be tailored to support RBSP science studies: (1) the distances separating THEMIS spacecraft along their common orbit, (2) the portion(s) of the THEMIS orbit where fast survey mode observations (which include full particle distribution functions and high time resolution electric and magnetic field measurements) should be taken, and (3) the phenomena that can be used to trigger even higher resolution burst mode measurements.

Methodology

To address the aforementioned topics, I convened a tiger team comprised of scientists involved in both the RBSP and THEMIS projects: Jacob Bortnik (UCLA), Scott Elkington (LASP, Colorado), Shrikanth Kanekal (NASA/GSFC), Kunihiro Keika (NJIT), Ian Mann (University of Alberta), Jonathan Rae (University of Alberta), Andrey Runov (UCLA), Mikhail Sitnov (JHU/APL), Kazue Takahashi (JHU/APL), and Aleksandr Ukhorskiy (JHU/APL). In advance of a 2.5 hour telecon on March 2, 2011, I sent the members of the panel briefing material regarding the RBSP and THEMIS missions (in particular the notional plan for THEMIS operations defined in the THEMIS Proposal submitted to the 2010 Heliophysics Senior Review) and several members of the team replied with detailed consideration of the aforementioned topics. All members of the team joined and participated in the telecon.

Following a briefing by A. Ukhorskiy surveying possible scientific objectives for joint THEMIS-RBSP studies, the tiger team addressed each phase of the joint missions from RBSP launch to end of primary mission in June 2014. With the news that launch would be delayed until no earlier than mid-August 2012, I requested generation of new ephemiris, which became available in mid-August 2011, enabling me to revise the objectives and account for the new spacecraft configurations. The results of the team's discussions are presented in chronological order below. Italics identify the distinctive driving scientific objective(s) requiring both THEMIS and RBSP observations for each season.

The document below has been edited several times in response to follow up telecons and e-mail exchanges. This version dates from August 28, 2011, by which time the team had grown to include John Bonnell, Yoshizumi Miyoshi, Kazuo Shiokawa, and Drew Turner. Discussions concerning the inclusion of representatives from Russia's forthcoming Resonance mission were underway (Lev Zelenyi, Anatoli Petrukovich, Mikhail Mogilevsky). Yuri Shprits provided text regarding the need for spacecraft intercalibration.

Dawn-Dusk Differences (Fall 2012)

Science objective(s)

What are the cause(s) of dawn-dusk differences in ion fluxes during geomagnetic storms? What role does the Kelvin-Helmholtz instability play in particle energization, transport, and loss? What are the relative roles of EMIC waves in the dusk magnetosphere, chorus waves in the dawn magnetosphere, and hiss deep within the magnetosphere?

Discussion.

During the Fall of 2012, the apogees of the THEMIS spacecraft will be near dusk local times, while those of the RBSP spacecraft will be near dawn (Figure 1). This orbital configuration enables simultaneous pre- and post-midnight measurements of plasmapause, plumes, ring current ion fluxes, pitch angle distributions, radial pressure gradients, and electric and magnetic fields. These observations are needed to resolve puzzling results from IMAGE ENA observations indicating enhanced ion fluxes post- (rather than pre-) midnight during geomagnetic storms. Since ions are expected to drift westward, these unexpected results have been attributed to skewed electric fields associated with shielding of the convection electric field [Brandt et al., 2002; Fok et al., 2003].

However, they may also result from dawn/dusk differences in ion pitch angle distributions (PADs), in particular butterfly PADs at dawn and pancake PADs at dusk. Small separation distances between the THEMIS spacecraft and fast survey mode from geosynchronous to perigee are desirable for these purposes.

At apogee, THEMIS will observe Kelvin-Helmholtz waves at and near the dusk magnetopause, potential drivers for particle radial transport, energization, and loss. Deeper within the magnetosphere, the THEMIS spacecraft will observe the ion distributions responsible for the generation of duskside EMIC waves, while RBSP observes electron distributions affected by dawnside chorus. In conjunction, the relative importance of these particle acceleration and loss mechanisms can be evaluated. Small interspacecraft separations and fast mode survey operations in the inner magnetosphere are desired for these purposes. Burst modes triggered on EMIC wave activity are of interest. Near perigee, THEMIS will frequently intersect the RBSP orbit near the noon and midnight meridians, permitting studies relating plasmaspheric hiss to chorus at these local times.

Recommendations for THEMIS

The studies described above require small interspacecraft separation distances, consistent with current plans for operations during the extended mission of THEMIS. They also require fast survey mode from geosynchronous through perigee to study ion flux levels and pitch angle distributions, chorus, hiss, and EMIC mode waves. Occasional burst modes triggered by encounters with the plasmapause and plumes would enable detailed studies of the waves that occur at these boundaries. More generally, there is interest in burst modes to be triggered by EMIC wave activity. Small, string of pearls, separation distances between the spacecraft will permit detailed studies of structures at the plasmapause and plumes.

Comments

None.

Particle loss at the dayside magnetopause (Winter 2012-2013)

Science objective(s)

How significant is particle loss via outward radial transport and magnetopause loss? How do solar wind pressure pulses and ULF waves energize magnetospheric particles? What is the relationship between low and high frequency ULF waves? What role to ion injections and plasma plumes play in generating EMIC waves?

Discussion

During the Winter of 2012-2013, the apogees of the THEMIS spacecraft will be near local noon, while those of the RBSP spacecraft will be just prior to dawn (Figure 2). According to current plans, the hours separating the THEMIS spacecraft along their identical orbits will be 4, 8, and 12. With apogees of 11.7 R_E, the THEMIS spacecraft will routinely cross the magnetopause and enter the magnetosheath, where they can observe the shocked solar wind input into the magnetosphere. Drivers to be observed in the magnetosheath include southward IMF turnings and transmitted solar wind pressure pulses. On board moments will suffice for the purposes of joint studies with RBSP.

Just before and after reaching apogee, the THEMIS spacecraft will frequently be at local times just before and after local noon, enabling them to assess magnetopause losses. In conjunction with RBSP observations on open drift shells deeper within the dawnside magnetosphere, THEMIS observations can be used to search for evidence of the outward diffusion and transport needed to supply electron shadowing. For these purposes, accurate pitch angle distributions are needed, necessitating operations in fast survey mode. To study magnetopause losses, separation distances of several hours in local time bounding local noon near apogee would be ideal.

EMIC waves are common throughout the dayside magnetosphere. Possible causes include enhanced instability rates associated with plasmaspheric plumes, greater particle anisotropies induced by fast mode waves transmitted into the magnetosphere by solar wind pressure enhancements, anisotropies caused by drift-shell splitting, ion injections, and finally the motion of particles drifting through the dayside magnetosphere on off-equatorial Shabansky orbits. Fast mode survey observations by THEMIS would provide the high frequency electric and magnetic field observations, Poynting flux and detailed pitch angle distributions needed to test these hypotheses. Both large and small interspacecraft separation distances are of interest, since the former provides information concerning the spatial extent of the wave field, while the latter might provide information concerning the detailed structure of plumes. RBSP, near dawn, will supply information concerning ion composition.

Both THEMIS and RBSP will frequently be located deep within the magnetosphere, in the afternoon and midnight to post-midnight regions, respectively. During very strong events that extend deep into the magnetosphere, the simultaneous observations that this configuration enables provide opportunities to track ion injections, describe their evolution, and that of the EMIC waves that they generate. Such studies will benefit from pitch angle distributions obtained by THEMIS during fast survey mode.

Large THEMIS interspacecraft separation distances in the dayside magnetosphere provide opportunities to track the motion of fast mode waves launched by interplanetary shocks and tangential discontinuities through the magnetosphere and assess their ability to energize magnetospheric particles rapidly. The same large separation distances will enable researchers to determine the extent and amplitude of compressional ULF wave fields that can trigger Pc1 pulsations by energizing magnetospheric particles and enhancing particle anisotropies. Studies like these will require fast survey mode observations, and triggers for burst mode operation based on signatures of abrupt magnetospheric compressions. In particular, the fast mode waveform electric field observations will be needed to validate spin-fit electric field measurements of electric field variations during Pc pulsations, and determine whether observations from the long- and short- boom pairs agree.

Recommendations for THEMIS

Consistent with the planned 4-8-12 hour time lags separating the THEMIS spacecraft along their orbit during this season, most of the scientific objectives described above require large interspacecraft separation distances. Fast mode observations are desired on the inbound and outbound legs of the orbit, including the plasmasphere, but excluding observations in the magnetosheath at apogee. There is a strong interest in burst mode triggering by transmitted interplanetary shocks, intense EMIC wave activity, and encounters with plasmaspheric plumes. Fast mode operations for THEMIS are desired in the post-noon sector at times when plasmaspheric plumes are expected, because waveform observations are needed to validate electric field observations.

Dawnside waves and electron drift (Spring 2013)

Science objective(s)

What are the radial profiles for chorus and magnetosonic mode wave activity? What processes energize and remove electrons along their drift paths from the nightside to the dawn magnetosphere? How do the fast mode waves launched by pressure pulses and Kelvin-Helmholtz activity in the dawnside magnetosphere couple to transverse mode waves deeper within the magnetosphere?

Discussion

During Spring 2013, the apogees of the THEMIS spacecraft will be near local dawn, while those of the RBSP spacecraft will be near midnight (Figure 3). According to current plans, the hours separating the THEMIS spacecraft along their identical orbits will be 4, 8, and 12.

Simultaneous observations from the inner portions of the THEMIS orbits and RBSP at apogee will define the radial extent, MLT extent, and characteristics of chorus and magnetosonic (frequencies from 10's of Hz to the lower hybrid) wave modes inside the RBSP apogee. Spacecraft separation distances on the order of several Earth radii, fast survey mode operations on the inner portions of the spacecraft orbit, and bursts determined by chorus wave activity at L = 5-7 are desired for this objective. An even better scenario would result if two THEMIS spacecraft could be close to each other and the third several Earth radii away.

THEMIS and RBSP will occasionally be in close proximity as they pass through the pre-dawn magnetosphere, facilitating studies of radial phase space density gradients. Fast survey mode operations in the inner magnetosphere would permit high resolution observations of relevant particle pitch angle distributions.

Observations from the two missions will be used to study the drift of electrons from RBSP locations near midnight to THEMIS locations in the dawn magnetosphere. Comparisons of phase space densities and pitch angle distributions will help determine loss via chorus wave scattering between the spacecraft in the two missions. Large separation distances and fast survey mode operations are also needed on the inbound leg of the THEMIS orbits for this objective.

At apogee, the THEMIS spacecraft will be ideally located to determine the characteristics of Kelvin-Helmholtz induced pulsations on the dawn flank of the magnetosphere. At nightside apogee, RBSP will be on drift shells that map to the vicinity of the magnetopause during periods when the magnetosphere is greatly compressed and/or the magnetotail greatly stretched. No special requirements are placed upon the THEMIS mission for the objectives during this season, which include identifying the amplitude and frequency of wave activity at the magnetopause for comparison with RBSP observations of the fast mode compressional waves that they launch into the magnetosphere and the transverse mode waves that these fast mode waves couple to and excite deeper within the magnetosphere.

Recommendation for THEMIS

Consistent with the planned 4-8-12 hour THEMIS interspacecraft separations, the proposed research generally requires separation distances greater than several Earth radii. Fast survey mode observations throughout the inbound leg of the spacecraft orbits, with burst modes keyed to magnetosonic, chorus, and EMIC mode activity are desirable. A possible trigger for bursts on magnetosonic mode activity would be rapid 200-300 pT variations in the compressional component of the magnetospheric magnetic field. This might be obtained from filter bank observations in the frequency range from 10 to 30 Hz.

Ion Injection, Energization, and Drift (Summer 2013)

Science objective(s)

What processes affect steady and transient ion injections into the ring current as they drift from the nightside to the dusk magnetosphere? What is the relationship between auroral pulsations, hiss, and chorus waves?

Discussion

During Summer 2013, the apogees of the THEMIS spacecraft will be located post-midnight, while those of the RBSP spacecraft will be located post dusk (Figure 4). Here THEMIS will observe both steady-state convection and the injection of plasma sheet ions, while RBSP will observe the response of the ring current and the growth of EMIC waves on ion drift paths that lead to the dusk magnetosphere. Consistent with current plans for 4-8-12 hour separations of the THEMIS spacecraft along their common orbit, wide spacing between the THEMIS spacecraft will ensure nearly continual measurements of the 10's-100's keV particle source population and source processes. However, small interspacecraft separations of several Earth radii would enable THEMIS to observe small-scale injection structure (e.g. flow channels) and the properties of large wave number ULF mode Pc5 oscillations. In either case, fast survey mode operations on the outbound leg of the orbits and in a broad region around apogee would facilitate efforts to catch the details of the injection processes (e.g., dipolarization). Burst modes triggered on dipolarization fronts are also of great interest.

Simultaneous THEMIS and RBSP observations during this season offer opportunities to study the relationship between plasmaspheric hiss (RBSP) and chorus waves (THEMIS) in the dawnside magnetosphere, to relate ground-based THEMIS observations of pulsating aurora to magnetospheric chorus activity, and to determine radial phase space density profiles. Fast survey mode operations on the inbound legs of THEMIS orbits that pass through the vicinity of RBSP would facilitate these studies, as would small interspacecraft separation distances.

Finally, there will be prolonged intervals when the trajectories of the RBSP and THEMIS spacecraft lie nearly parallel and close to one another in the pre-midnight magnetosphere, enabling interspacecraft calibration late in the mission.

The same orbits offer opportunities to study the radial profiles of energetic particles in the radiation belts, which may provide important clues concerning the processes operating on those particles, including injection, acceleration, diffusion, transport, and loss.

Recommendations for THEMIS

In general there is a preference for wide spacecraft separations to ensure continual monitoring of the particle source population in the plasma sheet and determination of radial phase space density profiles. Also, in general, there is a desire for fast survey mode operations on the outbound leg of the orbits and near apogee. However, occasional fast survey mode operations on the inbound leg of the orbit, near the expected position of the plasmapause, would aid studies of chorus and hiss. Burst mode operations are desired on dipolarizations, plasmapause encounters, and EMIC wave activity.

Duskside EMIC (Fall 2013)

Science objective(s)

What are the characteristics of the EMIC and drift mirror mode waves generated by injected ions in the duskside ring current, and what are the effects of these waves on radiation belt electrons?

Discussion

During Fall 2013, the apogees of both THEMIS and RBSP will be in the duskside magnetosphere (Figure 5). The multipoint observations obtained from these orbits are ideal to study post-injection ions and the EMIC/drift mirror waves that they generate. Large THEMIS and RBSP interspacecraft separation distances enable instantaneous determination of the global extent of the wave fields. However, small separation distances between 2 of the 3 spacecraft will aid in quantifying the spatio-temporal evolution of the EMIC and mirror mode waves. In particular, azimuthal separation distances on the order of 0.1 to 2 R_E will enable estimations of the azimuthal wave numbers of mirror mode waves, a key factor needed to determine their ability to interact with energetic electrons via drift-bounce resonances. Fast survey mode operation in the region between geosynchronous orbit and the plasmapause would be particularly desirable to define the pitch angle distributions responsible for the EMIC waves.

While at apogee, the THEMIS spacecraft will observe the effects of the Kelvin-Helmholtz instability on the magnetopause. RBSP will monitor the resonant response, if any, deeper within the magnetosphere. Although no special THEMIS operations are required for observations of the Kelvin-Helmholtz instability, it is important to note that the presence of cold flowing plasma on the magnetospheric side of the magnetopause boundary often adversely impacts the utility of the THEMIS electric field measurements. Waveform observations from fast survey mode will be essential to validate THEMIS electric field observations under these conditions. Intermediate (1-4 R_E) azimuthal interspacecraft separations will enable determination of the low azimuthal wave numbers anticipated for ULF waves driven by the Kelvin-Helmholtz instability.

Observations during this season offer an opportunity for continued studies defining the relationships between pulsating aurora, hiss, and chorus undertaken in previous years and to study radial profiles. In particular, they can be used to study the extent of chorus emissions in the nightside magnetosphere. As these studies will have been conducted earlier, they place no special requirements on operations in this season.

Recommendation for THEMIS

Wide interspacecraft separations (consistent with current plans for the extended THEMIS mission) and fast survey mode operations from plasmapause to geosynchronous orbit.

Effects of Solar Wind Pressure Variations (Winter 2013-2014)

Science objective(s)

What role do transmitted interplanetary shocks play in energizing radiation belt particles and generating EMIC waves?

Discussion

During Winter 2013-2014, the apogees of both the THEMIS and RBSP spacecraft will be in the mid-afternoon (see Figure 6). Large interspacecraft separation distances will enable the combined THEMIS and RBSP spacecraft missions to track transmitted fast mode waves through the magnetosphere, determine their characteristics, and quantify their attenuation. However, smaller separation distances between two or three THEMIS spacecraft would enable better local determination of wave front orientation and structure. Fast survey mode observations at and beyond the plasmapause will enable researchers to study the generation of EMIC mode waves by particle distributions made more anisotropic by the passage of these transmitted fast mode waves and/or compressional Pc waves. THEMIS observations of EMIC waves will be compared with RBSP observations of relevant particles distributions and EMIC waves deeper within the magnetosphere.

Recommendation

Consistent with current plans for the THEMIS mission, large interspacecraft separation distances and fast mode survey on inbound and outbound legs of the orbit are desired. Fast survey mode observations will provide the electric field waveform observations needed to validate electric field observations at times when plasmaspheric plumes are observed. Burst mode should be triggered by sudden compressions of the dayside magnetosphere, as evidenced by step function increases in electric and magnetic field strengths exceeding specified levels.

ULF Waves (Spring 2014)

Science objective(s)

What is the global distribution of ULF waves, including low amplitude waves deep within the magnetosphere?

Discussion

During Spring 2014, the apogees of both the THEMIS and RBSP spacecraft will be at pre-noon local times (see Figure 7). This is a good configuration to study the characteristics of ULF waves, both those generated by processes internal to the magnetosphere and those generated by the Kelvin-Helmholtz instability on the magnetopause. Large interspacecraft separations are desired for continual monitoring. In view of the absence of other requirements for fast survey and/or burst mode, this is a good season to take high time resolution electric and magnetic field observation needed for accurate determination of low amplitude waves deep within the magnetosphere. Working in conjunction with each other, the RBSP and THEMIS missions will determine the characteristics of these waves, including their spatial extent.

The presence of both RBSP and THEMIS within the dayside magnetosphere offers an opportunity to survey dayside chorus observations on a statistical basis.

Recommendation

Large interspacecraft separation distances and fast survey mode operations on the approaches to perigee.

Electron injection (Summer 2014)

Science objective(s)

What waves do injected electrons generate and what is the effect of these waves on radiation belt electrons?

Discussion

During Summer 2014, the apogees of the THEMIS spacecraft will be at post midnight local times, while those of the RBSP spacecraft will be near dawn (see Figure 8). These orbits are ideal for multipoint local studies of injected electrons drifting through the dawnside magnetosphere, their energization, and the waves they generate. To make the observations of injected plasma needed for such joint studies, fast survey mode is desired at apogee and throughout the inbound legs of the THEMIS orbits, with burst modes triggered by dipolarization. Large separation distances would enable continual THEMIS monitoring of the nightside input, while small interspacecraft separations would enable studies of high wave number ULF waves. Operating in the dayside magnetosphere, the RBSP spacecraft will observe the injected electrons as they drift eastward, and the waves that they generate.

Recommendation for THEMIS

Large interspacecraft separation distances, fast survey mode at apogee and on inbound legs of spacecraft orbits, burst mode triggered by dipolarization events.

Throughout the Mission

Finally, there are some recommendations for THEMIS that are valid throughout the mission. Fast survey operations deep within the magnetosphere return the high time resolution magnetic field observations needed to remove spin tone and other artifacts from the magnetometer data set, thereby enabling studies of low-amplitude Pc3-5 waves. Occasional fast mode operations at L shells ranging from 2 to 7 would greatly benefit these studies.

Figure 1. THEMIS and RBSP orbits on October-November, 2012.

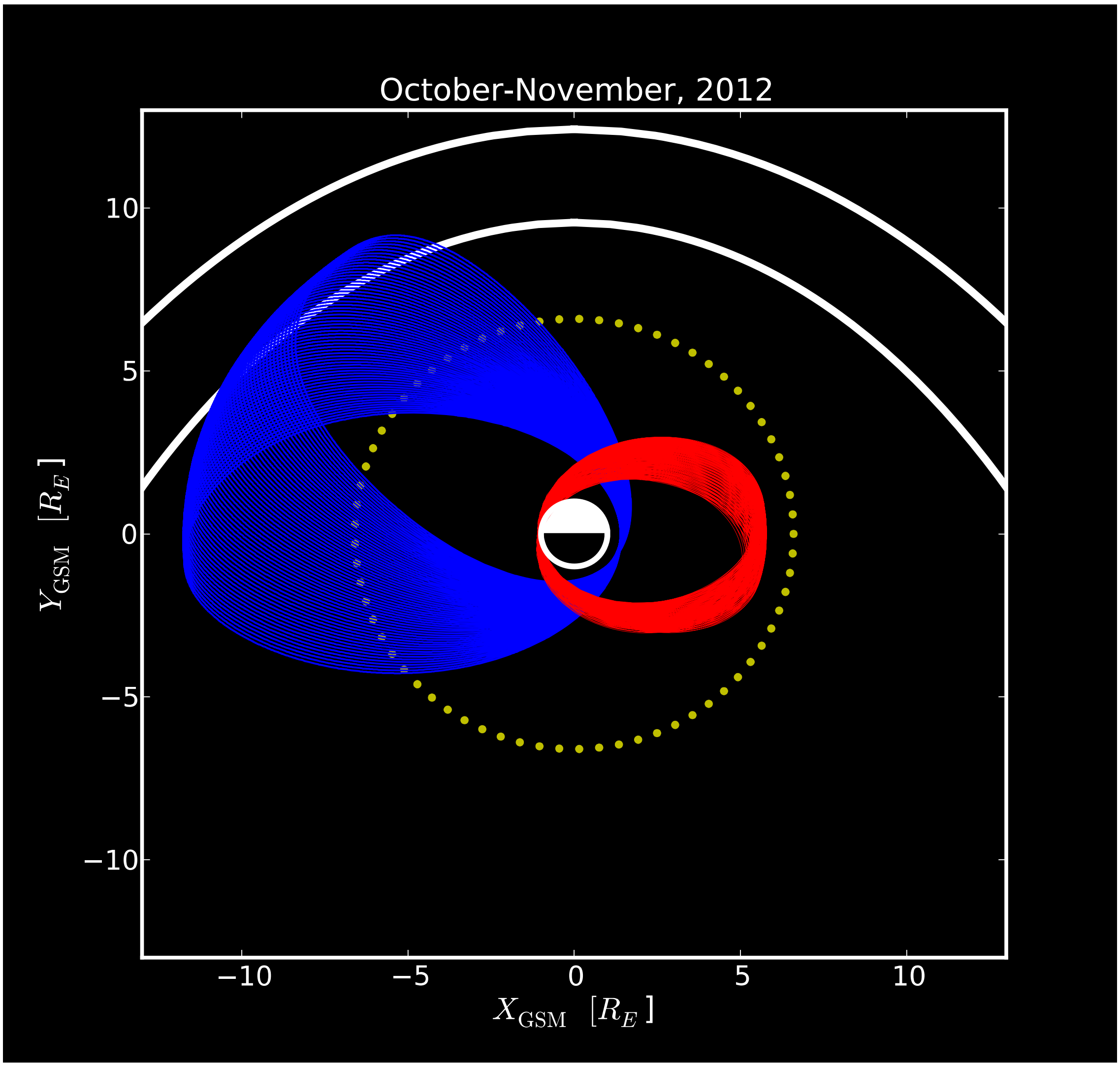

Figure 2. THEMIS and RBSP orbits on January-February, 2013.

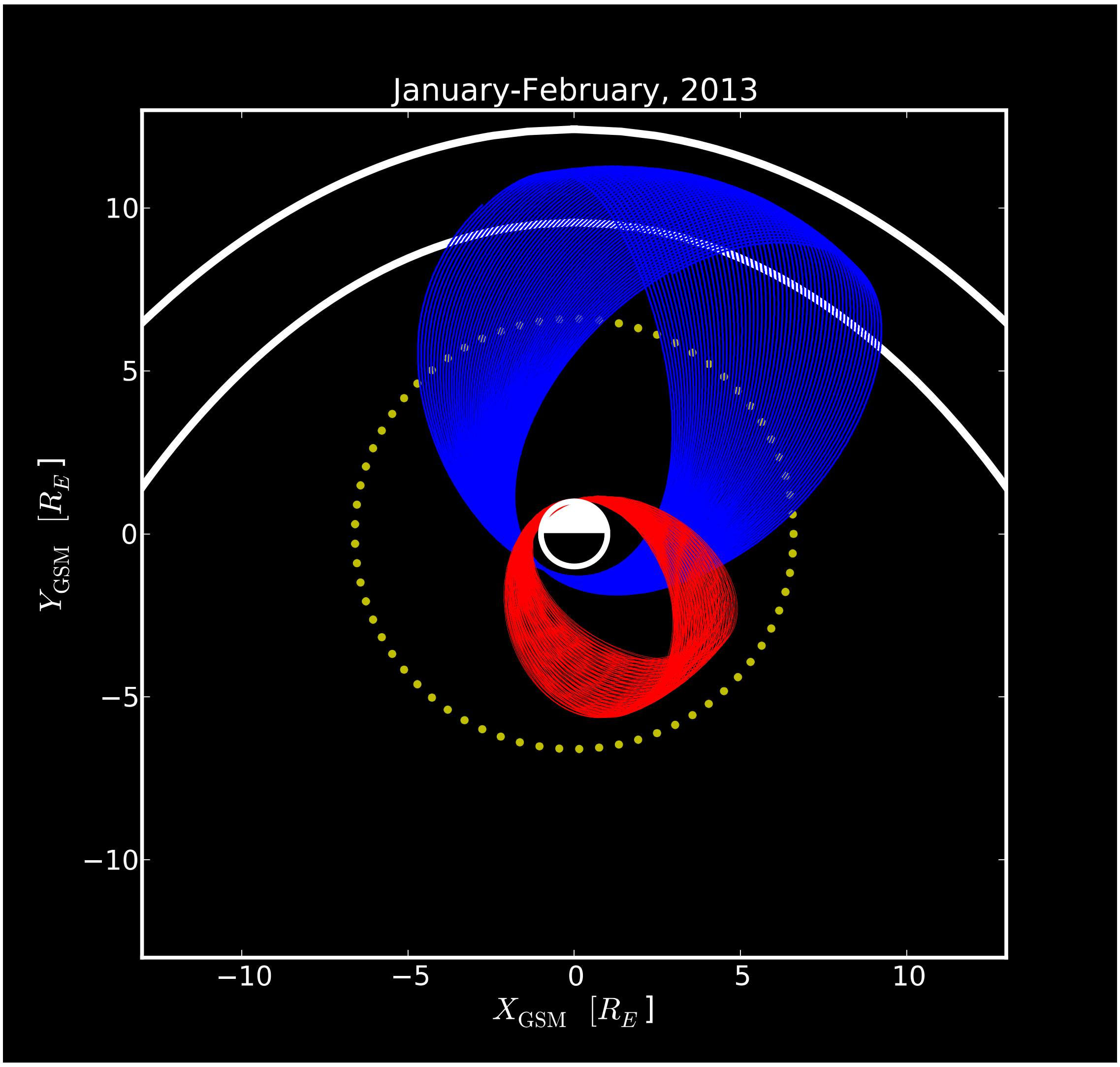

Figure 3. THEMIS and RBSP orbits on March-April, 2013.

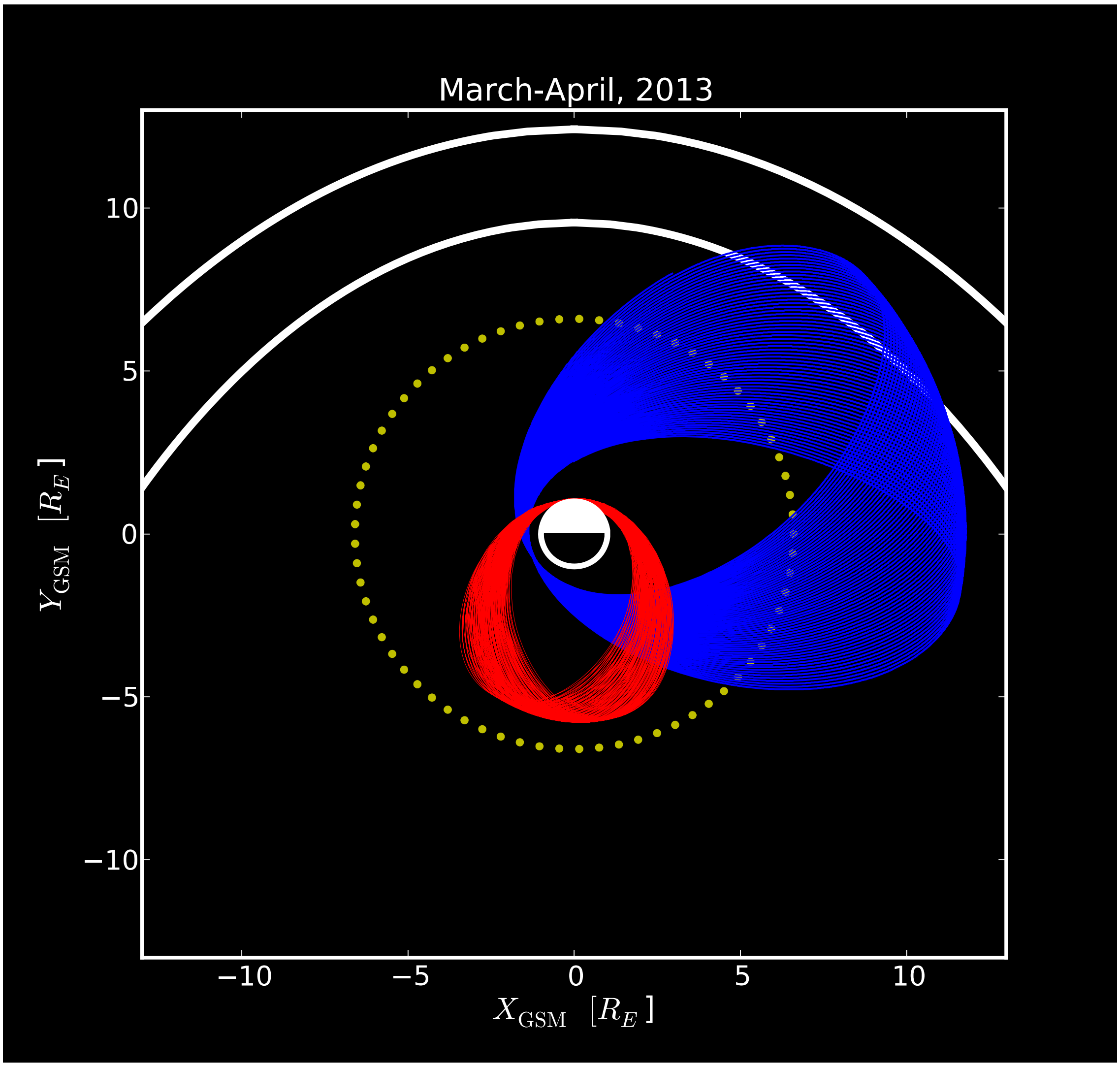

Figure 4. THEMIS and RBSP orbits on July-August, 2013.

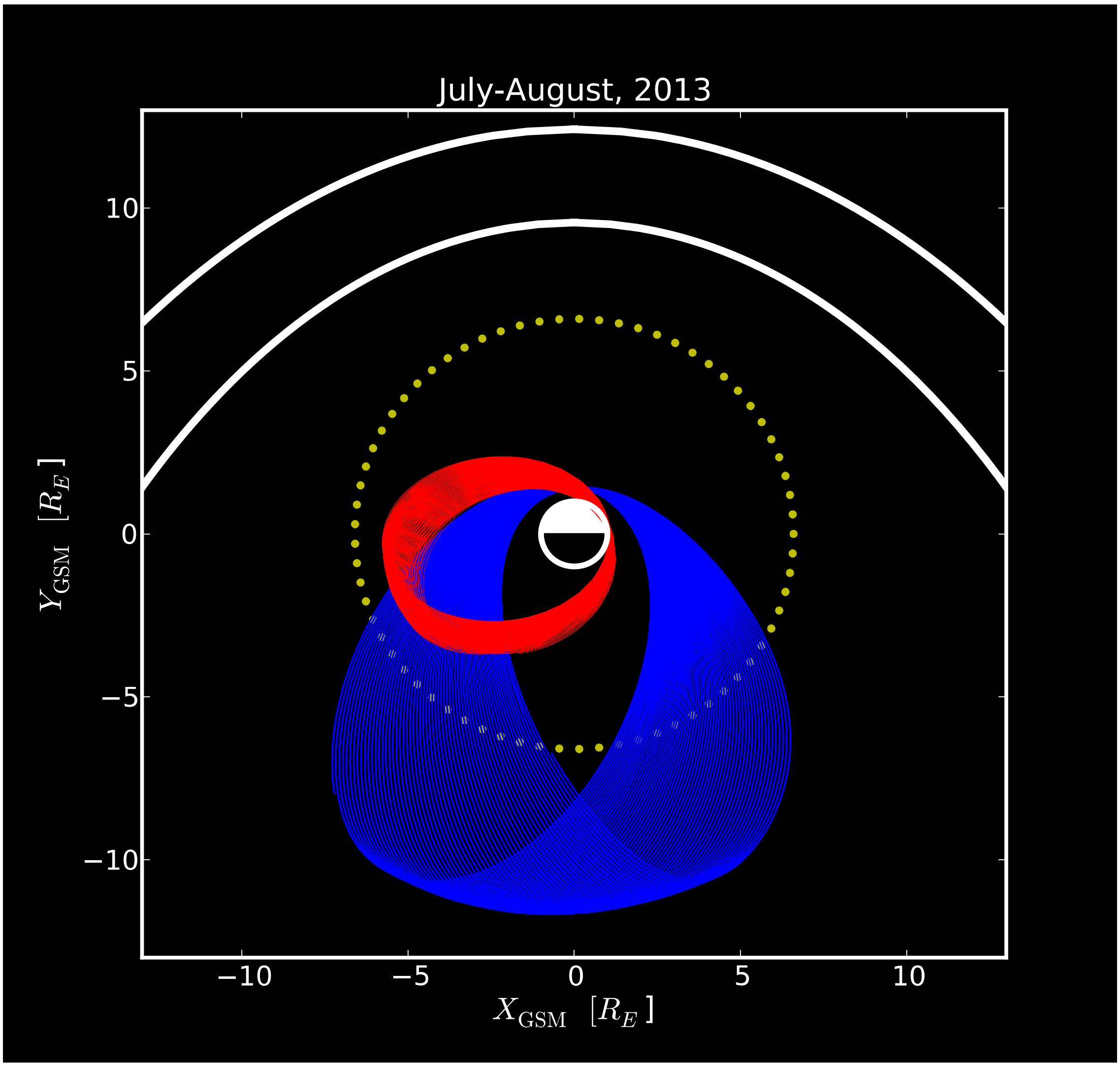

Figure 5. THEMIS and RBSP orbits on October-November, 2013.

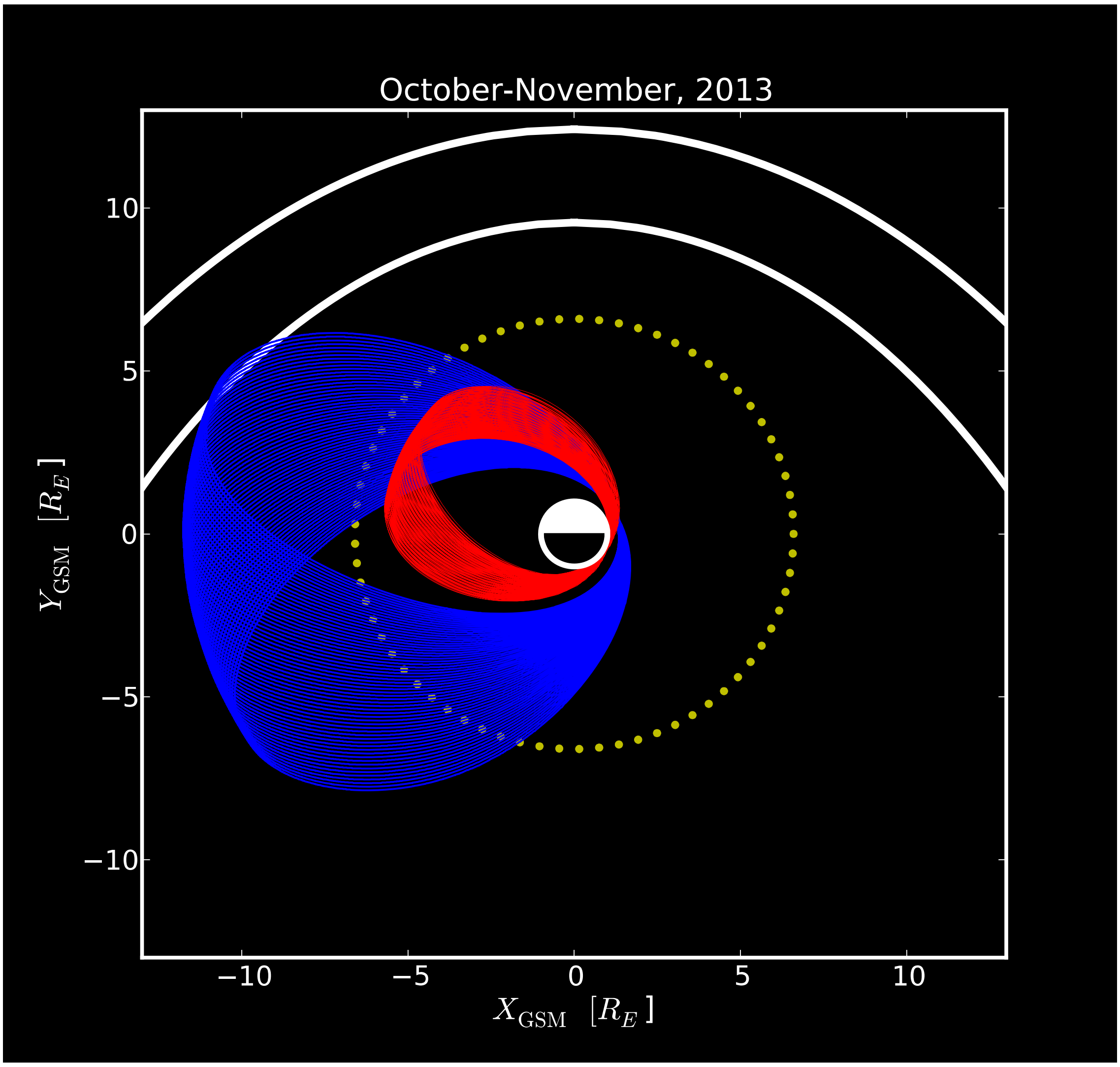

Figure 6. THEMIS and RBSP orbits on January-February, 2014

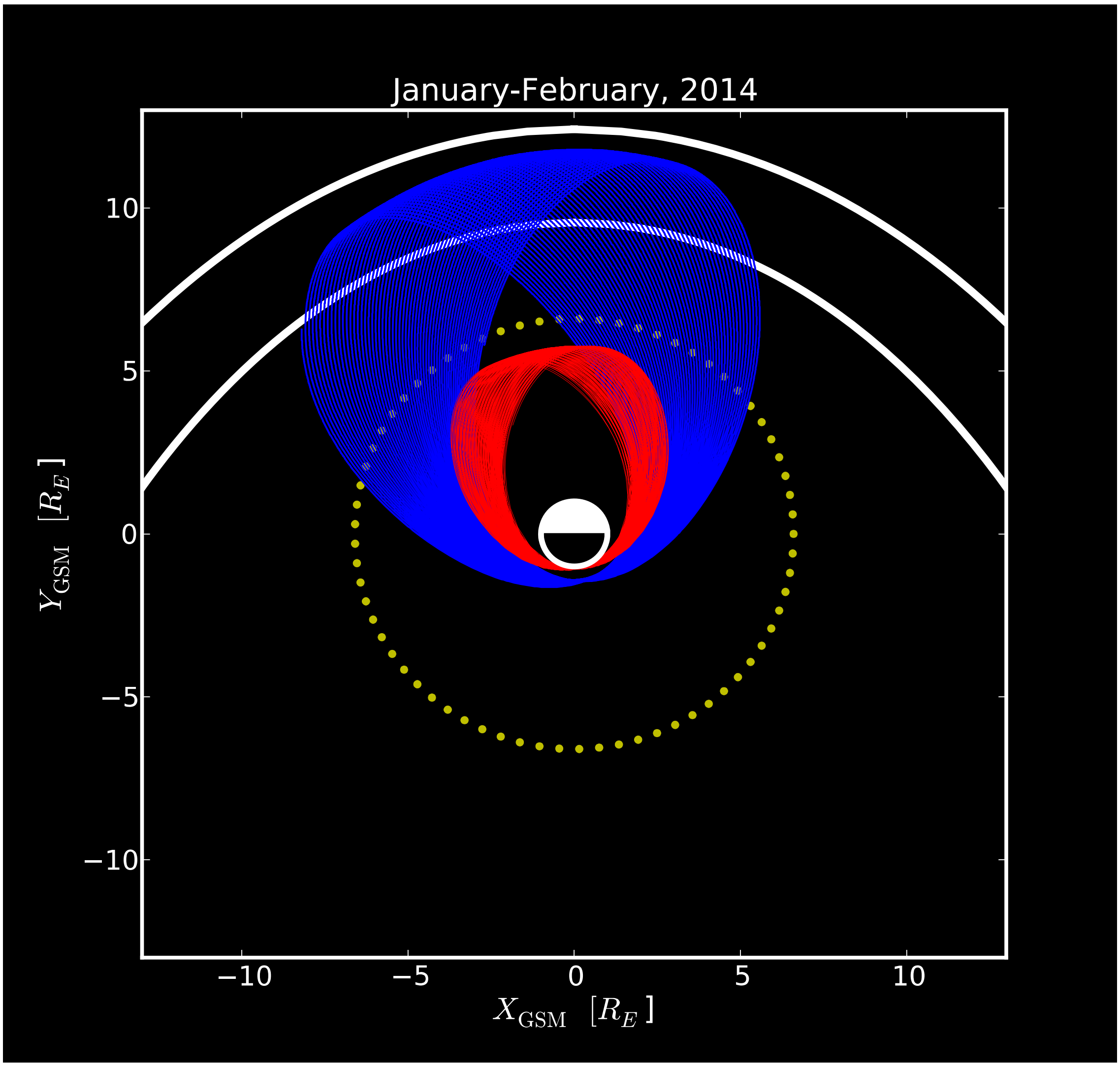

Figure 7. THEMIS and RBSP orbits on March-April, 2014.

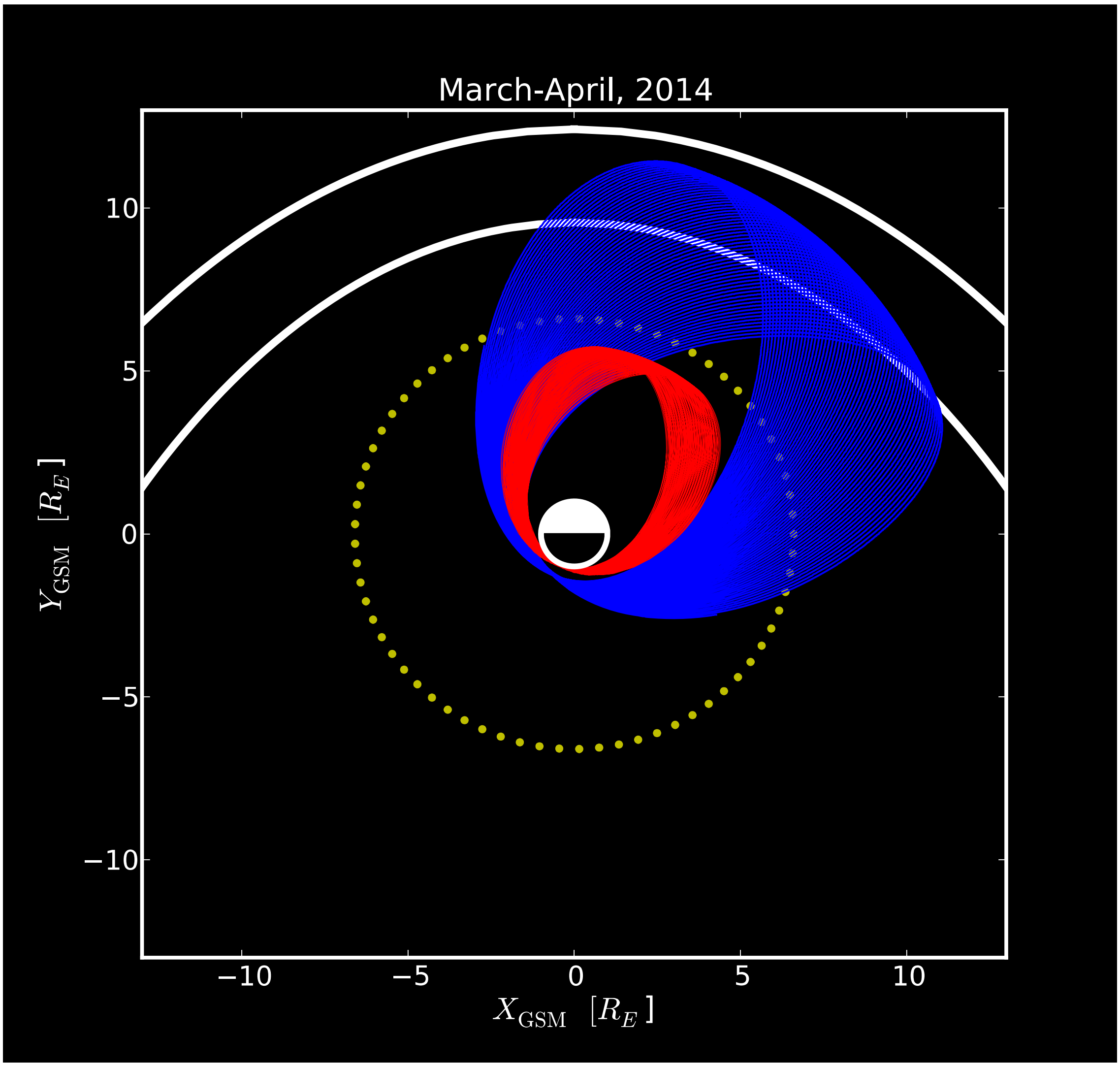

Figure 8. THEMIS and RBSP orbits on July-August, 2014.