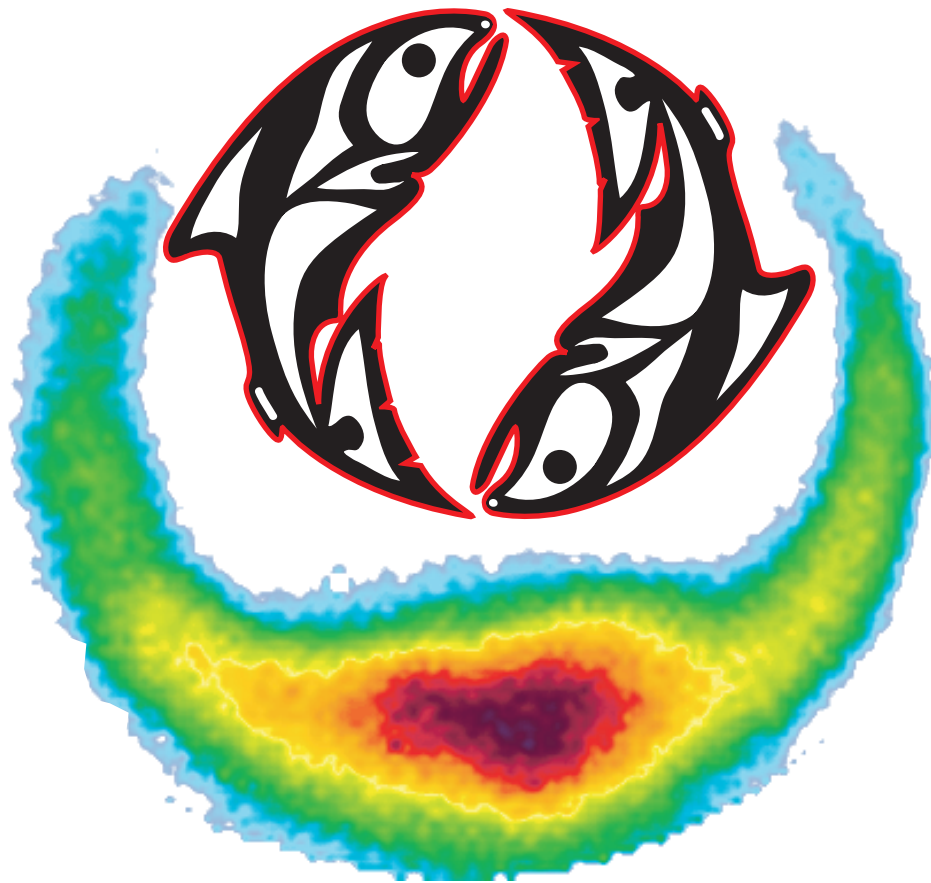


*Sixth International  
Conference  
on  
Substorms*



*Edited by  
R. M. Winglee*

**Sixth International Conference  
on Substorms**

University of Washington, Seattle

March 25-29, 2002

Edited by

R. M. Winglee

Cover: Image of the northern auroral oval taken by the Ultraviolet Imager (UVI) on the Polar spacecraft. The convection pattern is symbolized through the northwest style of two salmon. Image developed by D. Chua, M. Fillingim and J. Cascarden.

The organizers of the conference gratefully acknowledge support from NASA, NSF, and AFOSR.



ISBN: 0-9711740-3-2

The University of Washington and the Sixth International Conference on Substorms received a nonexclusive license to use, publish, and reproduce the papers from their respective authors. You agree to treat all texts and graphics as the intellectual property of their respective authors. The statements, opinions and conclusions expressed in this publication are those of the authors and not necessarily those of the University of Washington or the ICS6 co-sponsoring organizations.

With many thanks to Stacy Williamson and assistants Debra Bryant, Emily West, and Christy Pack at the conference and Heather Davis, Heidi Delaney, and Awad Awad working behind the scenes. Their unfaltering support throughout ensured that all attendees had a productive conference.

To Erika Harnett, Damien Chua, Matt Fillingim, Carol Paty, and John Williams for conference technical support – may your studies take you along the road to your dreams.

*For Jennifer, Kathryn and Matthew*

## **Preface**

<i>R. M. Winglee</i> .....	xi
----------------------------	----

## **Plenary Talks**

### **Why We Have Not Yet Solved the Substorm Problem**

<i>G. Rostoker</i> .....	1
--------------------------	---

### **What Do the Auroral Electrojets Tell Us About Substorm Dynamics?**

<i>Y. Kamide and K. Seki</i> .....	9
------------------------------------	---

### **A New Attempt to Understand Magnetospheric Substorms by Synthesizing the Three Well-Established Observations**

<i>S.-I. Akasofu</i> .....	17
----------------------------	----

### **Particle Simulation of the Cross-field Current Instability in a Thin Current Sheet**

<i>A. T. Y. Lui</i> .....	25
---------------------------	----

### **Collective Behavior and Magnetospheric Substorms**

<i>D. N. Baker, A. J. Klimas, and D. Vassiliadis</i> .....	33
--	----

### **Ionospheric Signatures of Magnetospheric Particle Acceleration in Substorms – How to Decode Them?**

<i>V. A. Sergeev</i> .....	39
----------------------------	----

### **Substorms: Externally Driven Transition to Unstable State a Few Minutes Before “Onset”**

<i>L. R. Lyons, I. O. Voronkov, J. M. Ruohoniemi, and E. F. Donovan</i> .....	47
---	----

### **Substorm Expansion Onsets Observed by Cluster**

<i>R. Nakamura, W. Baumjohann, H. Noda, G. Paschmann, B. Klecker, P. Puhl-Quinn, J. Quinn, R. Torbert, A. Balogh, H. Reme, H. U. Frey, C. J. Owen, A. N. Fazakerley, and J. P. Dewhurst</i> .....	55
---	----

## **High Latitude Processes**

### **Substorm Development as Seen Through Coordinated Multi-instrument Observations**

<i>G. Lu, E. F. Donovan, T. Nagai, T. Mukai, D. Lummerzheim, G. K. Parks, L. A. Frank, H. J. Singer, M. B. Moldwin, J. L. Posch, M. J. Engebretson, and J. Watermann</i> .....	63
--	----

### **What is the Interrelation between Polar Cap and Substorm Processes?**

<i>K. Kauristie, K. Liou, L. Lazutin, O. Amm, A. Viljanen, P.T. Newell, and J. Weygand</i> .....	71
--	----

### **Simulation of Discrete Auroral Arcs**

<i>D. S. Evans, M. Roth, J. De Keyser, J. Lemaire, and V. Pierrard</i> .....	79
--	----

### **Ionospheric Convection during Magnetospheric Substorms**

<i>M. Lester</i> .....	85
------------------------	----

### **Multipoint Observations of a Pi2 Pulsation on Morning Side**

<i>M. Nosé, K. Takahashi, T. Uozumi, K. Yumoto, D. K. Milling, and P. R. Sutcliffe</i> .....	93
--	----

<b>Magnetospheric Response to the Solar Wind Dynamic Pressure Inferred from the Polar Cap Index</b> <i>R. Lukianova and O. Troshichev</i> .....	99
<b>Relationship of Oscillating Aurora to Substorms and Magnetic Field Line Resonances</b> <i>J. A. Wanliss and R. Rankin</i> .....	105
<b>Near-Conjugate Magnetic Substorms at Very High Latitudes Observed by Greenland and Antarctic Ground Magnetometers and Ørsted Satellite</b> <i>V. O. Papitashvili, C. R. Clauer, F. Christiansen, Y. Kamide, V. G. Petrov, O. Rasmussen, and J. F. Watermann</i> .....	110
<b>Ionospheric Potential Model for the Development of a Substorm</b> <i>S. Taguchi, and H. Nishimura</i> .....	115
<b>Implications of Ionospheric Substorm Electrodynamics Model</b> <i>J. W. Gjerloev and R. A. Hoffman</i> .....	123
<b>Azimuthal Substorm Propagation Inferred from an L-shell Chain of Ground-based Magnetometers</b> <i>B. J. Jackel and E. F. Donovan</i> .....	129
<b>Influence of the Cosmic Rays and Solar Wind Variations on Atmospheric Temperature in the Southern Polar Region</b> <i>O. A. Troshichev, L. V. Egorova, and V. Ya. Vovk</i> .....	135
 <b>Ionospheric Processes</b>	
<b>Ionospheric Influence on Substorm Development</b> <i>W. K. Peterson</i> .....	143
<b>Auroral Activity of the Polar Boundary Arc and the Equatorial Part of an Oval During Substorms</b> <i>L. Lazutin, K. Kauristie, T. Kornliova, and M. Uspensky</i> .....	151
<b>Multipoint Observations of the Ion Isotropy/b2i Boundary</b> <i>N. A. Nicholson, E. F. Donovan, B. J. Jackel, I. Voronkov, L. L. Cogger, D. Lummerzheim, F. Creutzberg, and T. Sotirelis</i> .....	157
<b>Polar Cap Boundary Auroral Ion Outflows During Substorms and Active Aurora</b> <i>Y.-K. Tung, G. K. Parks, C. W. Carlson, J. P. McFadden, D. M. Klumpar, W. J. Peria, and K. Liou</i> .....	163
<b>The Evolution of North-South Aligned Auroral Forms into Auroral Torch Structures: The Generation of Omega Bands and Ps6 Pulsations via Flow Bursts</b> <i>M. G. Henderson, L. Kepko, H. E. Spence, M. Connors, J. B. Sigwarth, L. A. Frank, H. J. Singer, and K. Yumoto</i> .....	169
<b>Stepwise Auroral Substorm Evolution Observed by the Meridian Scanning Photometers at Syowa and Asuka Stations</b> <i>A. Kadokura, A.-S. Yukimatu, and M. Ejiri</i> .....	175

## Tail Processes

### *Modeling*

#### **Drift Instabilities in Current Sheet**

*P. H. Yoon* ..... 181

#### **The Challenge for Kinetic Simulations of Substorm Growth and Onset**

*P. L. Pritchett and F. V. Coroniti* ..... 189

#### **Relating Thin Current Sheet Formation and Tail Reconnection to Substorm Development**

*J. Birn, K. Schindler, and M. Hesse* ..... 197

#### **MHD Simulation of Energy Transfer From the Solar Wind Into the Magnetosphere**

*M. Palmroth, T. I. Pulkkinen, and P. Janhunen* ..... 205

#### **3D Magnetic Reconnection: An Investigation of the Properties of the Oblique Modes**

*G. Lapenta, and J.U. Brackbill* ..... 211

#### **Computer Simulations on Magnetic Field Dipolarization by the Spontaneous Fast Reconnection Model**

*M. Ugai, T. Shimizu and K. Kondoh* ..... 217

#### **Simulation of Cross-Field Instabilities in a Current Sheet for More Realistic Values of the Ion to Electron Mass Ratio**

*P. L. Pritchett* ..... 225

#### **The Significance of Tail Instabilities in Triggering Substorm Onset**

*M. I. Sitnov, A. S. Sharma, A. T. Y. Lui, P. H. Yoon, and P. N. Guzdar* ..... 231

#### **A Kinetic Model of Thin Current Sheet Generation and its Role in Magnetic Reconnection in Space Plasmas**

*V. I. Domrin and A. P. Kropotkin* ..... 239

#### **Catastrophic-Like Evolution of Thin Current Sheets Due to Non-Adiabatic Scattering Processes**

*L. M. Zelenyi, H. V. Malova, V. Yu. Popov, D. C. Delcourt, and A. S. Sharma* ..... 245

#### **Checking Interchange Stability of the Midtail Plasma Sheet**

*V. Golovchanskaya, and Y. P. Maltsev* ..... 253

#### **Plasma Sheet Flows During Substorm Growth and Expansive Phases**

*D. W. Swift* ..... 259

#### **Hybrid Code Simulation of Shock Size Asymmetry Caused by Charge Exchange**

*H. Shimazu* ..... 264

#### **Near-Earth Breakup in Substorms: Empirical and Model Constraints**

*I. O. Voronkov, E. F. Donovan, P. Dobias, J. C. Samson, and L. R. Lyons* ..... 270



## Observations

<b>Plasma Sheet Dynamics During Substorm from Global ENA Measurements onboard IMAGE</b> <i>P. C:son Brandt, D. G. Mitchell, S. Ohtani, E. C. Roelof, R. Demajistre, and J. -M. Jahn</i> .....	278
<b>Cluster Observations of the Postmidnight Plasma Sheet at 18 R<sub>e</sub> during Substorms</b> <i>R.L. McPherron, M.G. Kivelson, K.Khurana, O.Amm, J. B. Baker, A. Balogh, H. Rème, M. Connors, F. Creutzberg, I. Dandouras, I. Mann, D. Milling, M. B. Moldwin, G. Rostoker, C. T. Russell, and H. Singer</i> .....	283
<b>Interball Substorm Studies</b> <i>I. Sandahl</i> .....	291
<b>Do Interplanetary Shocks Really Trigger Substorm Expansion Phase Onsets?</b> <i>K. Liou, P. T. Newell, and C.-I Meng, C.-C. Wu, and R. P. Lepping</i> .....	299
<b>Radiation Belts and Substorm Particle Injections</b> <i>X. Li</i> .....	305
<b>Energetic Electron Bursts Before the Main Substorm Injection</b> <i>T.V. Kozelova, L.L. Lazutin, and B.V. Kozelov</i> .....	312
<b>Substorm-Associated Magnetic Field Fluctuations Around X=-10 Re</b> <i>K. Shiokawa, I. Shinohara, T. Mukai, and H. Hayakawa</i> .....	318
<b>Role of the Parallel Current Instability during Substorms: Theory and Observations</b> <i>O. Le Contel, A. Roux, S. Perraut, R. Pellat, P. Robert, G. Chanteur, D. Fontaine, N. Cornilleau-Wehrin, J.-A. Sauvaud, C. Cully, G. Parks, D. Chua, M. André, A. Balogh, A. Fazakerley, H. Rème, T. Nagai, T. Mukai, H. Hayakawa, A. Matsuoka, R. R. Anderson, and H. Matsumoto</i> .....	326
<b>Electric Fields in the Vicinity of L=20 Re During Substorms</b> <i>C. E. McIlwain and S. S. Kerr</i> .....	334
<b>Fast Burst of High Energy Protons and Their Role in Triggering of the Substorm Onset Instability</b> <i>L. Lazutin, A. Korth, and T. Kozelova</i> .....	340
<b>Beamlet-like Non-dispersed PSBL Plasma Structures and Their Signatures in Auroral Region (Statistical Analysis of Interball-1 and -2 Observations)</b> <i>E. Grigorenko, A. Fedorov, J. A.Sauvaud, and L. Zelenyi</i> .....	346
<b>Distinct Magnetospheric Responses to Southward IMF in Two Substorms</b> <i>M. El-Alaoui, M. Ashour-Abdalla, R. L. Richard, L. A. Frank, W. R. Paterson, and J. B. Sigwarth</i> .....	352
<b>Statistical Assessment of the Magnetotail Current Contribution to Dst</b> <i>Y. P. Maltsev, and A. A. Ostapenko</i> .....	358
<b>Magnetic Field and Plasma Variations in the Mid-magnetotail Associated with Pseudo and Major Breakups</b> <i>H. Nakai, Y. Kamide, and M. Brittnacher</i> .....	364
<b>Observations of Two-Stage Substorm Onsets in the Near-Earth Plasma Sheet</b> <i>G. M. Erickson, N. C. Maynard, and G. R. Wilson</i> .....	370
<b>Observations of Substorms during Prolonged Northward Interplanetary Magnetic Field</b> <i>C.-C. Wu, K. Liou, R. P. Lepping, G. Le, and C.-I. Meng</i> .....	376

<b>Comparison of Plasma Sheet and Auroral Electron Energy Fluxes During Substorms</b> <i>M. O. Fillingim, G. K. Parks, R. P. Lin, and D. Chua</i> .....	382
--	-----

<b>The Dawn-Dusk Asymmetry of Energetic and Thermal Electrons: The Geotail Observation</b> <i>S. Imada, M. Hoshino, and T. Mukai</i> .....	388
---	-----

## **M/I Coupling**

<b>A Possible Role of CPS Ions of Ionospheric Origin in Substorm Onset</b> <i>C. M. Cully, E. F. Donovan, A. W. Yau, and H. J. Opgenoorth</i> .....	394
--	-----

<b>Substorm Observations Combining Ground-based Instruments and Cluster</b> <i>E. Borälv, H. J. Opgenoorth, J. –M. Bosqued, J. P. Dewhurst, A. Fazakerley, C. J. Owen, M. Dunlop, and M. Carter</i> .....	399
--	-----

<b>Influence of Ionospheric Processes on Substorm Activity</b> <i>R. M. Winglee</i> .....	404
--	-----

<b>GEOTAIL Observations of Variations in the Magnetotail Associated with Substorm Auroral Breakups</b> <i>Y. Miyashita, S. Machida, K. Liou, T. Mukai, Y. Saito, K. Tsuruda, H. Hayakawa, C.-I. Meng, and G. K. Parks</i> .....	410
--	-----

<b>Towards a Unified Theory of Substorm Growth, Expansion and Recovery Phases, Ring Current Formation and Substorm Injections</b> <i>G. Atkinson</i> .....	416
---	-----

<b>Modification of the Ionosphere – Magnetosphere Coupling by HF Pumping into Night-Side Auroral Ionosphere</b> <i>N. F. Blagoveshchenskaya, T. D. Borisova, V. A. Kornienko, M. T. Rietveld, B. Thidé, and M.J. Kosch</i> .....	422
---	-----

<b>Density Gradient Effects of Auroral Cavities: Studies on Magnetosphere-Ionosphere Coupling</b> <i>M. Prakash</i> .....	428
--	-----

<b>Dynamics of Auroral Intensification as an Output of Magnetosphere-Ionosphere System</b> <i>B. V. Kozelov, T. V. Kozelova, and T. A. Kornilova</i> .....	432
---	-----

## **Wave/Particle Processes**

<b>The Evolution of Substorm-enhanced Whistler-mode Waves and Their Relation to SCEs Seen on the Ground</b> <i>G. A. Abel, A. J. Smith, N. P. Meredith, and R. R. Anderson</i> .....	438
---	-----

<b>The Role of Waves in Magnetotail Dynamics</b> <i>C. Cattell, J. Dombeck, J. Wygant, F. S. Mozer, and M. André</i> .....	443
---	-----

<b>Ionospheric HF Pump Wave Triggering of Auroral Activation on October 2, 1998</b> <i>N. F. Blagoveshchenskaya, V. A. Kornienko, T. D. Borisova, M. T. Rietveld, and B. Thidé</i> .....	450
---	-----

## Storm/Substorm Processes

<b>Assessing the Importance of Convective and Inductive Electric Fields in Forming the Stormtime Ring Current</b> <i>M. W. Liemohn and J. U. Kozyra</i> .....	456
<b>Effects of Magnetic Storms on Substorm Evolution</b> <i>T. I. Pulkkinen, H. E. J. Koskinen, K. E. J. Huttunen, K. Kauristie, E. I. Tanskanen, M. Palmroth, and G. D. Reeves</i> .....	464
<b>A New Field-Aligned Current Index AF and Storm-Substorm Relationship</b> <i>W. Sun, G.-X. Chen, B.-H. Ahn, and S.-I. Akasofu</i> .....	472
<b>Comparative Study of Magnetospheric Configuration Changes During May 2, 1998 Moderate Storm and May 4, 1998 Intense Storm Events</b> <i>N. Yu. Ganushkina, T. I. Pulkkinen, M. V. Kubyshkina, and H. J. Singer</i> .....	478
<b>Non-substorm Mechanism for Magnetic Storms</b> <i>Y. P. Maltsev</i> .....	484
 <b>Modeling and Forecasting</b>	
<b>A Substorm Sequence Studied with Automated Forward Modeling</b> <i>M. Connors and G. Rostoker</i> .....	490
<b>Modeling and Forecasting of the Multi-Scale Features of Magnetospheric Dynamics during Substorms</b> <i>A.Y. Ukhorskiy, M. I. Sitnov, A. S. Sharma, and K. Papadopoulos</i> .....	496
<b>New Generation of Models for Substorm Forecasting from Multi-Scale and High-Dimensional Data</b> <i>S. B. Ganguli and V. V. Gavrishchaka</i> .....	502
<b>Modeling of Substorm Activity by the Discrete Model with Magnetosphere-Ionosphere Feedback</b> <i>B.V. Kozelov, and T.V. Kozelova</i> .....	508
<b>Averaged Behavior of the Solar Wind Parameters Around Breakups</b> <i>Y. P. Maltsev, A. A. Arykov, and I. V. Golovchanskaya</i> .....	514

## Preface

At this time substorms remain an enigma to space physics. Many of their gross features are well known. These include the typical solar wind conditions needed to provide the free energy to drive the substorms, the auroral manifestations associated with onset, and the typical reconfiguration of the magnetosphere through the growth and recovery phases, including tail thinning and expansion, magnetic reconnection, enhanced ionospheric outflows and the injection of energetic particles into the inner magnetosphere. What are presently missing are the details in linking the actions and reactions of different regions as the substorm develops. A full understanding of substorms is not going to be achieved unless we can fully map the flow of energy, momentum and mass from the solar wind into the magnetosphere and ionosphere, and the physical processes that control these flows.

In order to improve our understanding of some of these key processes, the Sixth International Conference on Substorms focused its attention on the processes that control the energization of plasma that links critical regions during substorms. These issues that were investigated include:

- What are the observational and theoretical particle/kinetic signatures for substorm processes?
  - particle acceleration processes - boundary layer processes versus bulk heating
  - ionospheric signatures of magnetospheric particle acceleration
  - manifestations of current sheet dynamics
  - role of reconnection in substorms - is reconnection a necessary condition for substorm onset or just a manifestation?
  - new insights from Cluster 2
- What are signatures of substorm ionospheric processes in the magnetosphere?
  - how do the structures seen at low altitudes reflect substorm development in the magnetosphere?
  - what are the magnetospheric signatures of Alfvén resonance heating, and ionospheric outflows and mass loading?
  - what is the relationship between fast local processes and the global reconfiguration?
  - new insights from IMAGE
- What are the macroscopic manifestations of ionospheric/magnetospheric coupling?
  - are there differences between quiet time and active time substorms, or in other words, is there feedback between the ionosphere and magnetosphere?
  - are there asymmetries produced by summer/winter hemispheric differences?
  - what is the influence of the formation, injection and loss of energetic particle populations in the overall development of a substorm?
- What are space weather effects, from the heating of the upper atmosphere, to the modification of the ionosphere and inner magnetosphere associated with solar wind drivers, and insights provided by global modeling?

These proceedings document both the state of our understanding prior to the conference and advances being made with new in-situ data and enhanced modeling. This compilation of papers represents about 66% of the actual papers presented. The debate on substorm processes remains lively, as evidenced by many fruitful discussions that were held during the conference. It is clear from the papers presented herein that substantial progress is being made in identifying key processes and their signatures in the particle and magnetic field data. The dilemma is that the new results show that the original paradigms may have been too simple and the system is much more complex and highly structured than previously envisioned. Resolving this complexity will have to await future studies.

In developing the themes discussed at the conference I wish to give thanks to the other members of the Program Committee including

G. Parks (*USA*), M. Brittnacher (*USA*), J. Burch (*USA*),  
O. de la Beaujardiere (*USA*), J. Drake (*USA*), R. Hoffman (*USA*),  
M. Hudson (*USA*) Y. Kamide (*Japan*), H. Koskinen (*Finland*),  
M. Lester (*UK*), G. Lu (*USA*), L. Lyons (*USA*), R. L. McPherron (*USA*),  
T. Mukai (*Japan*), E. S. Mobius (*USA*), J. S. Murphree (*Canada*),  
T. Nagai (*Japan*), S. Ohtani (*USA*), S. Perraut (*France*), A. Rodger (*UK*),  
I. Sandahl (*Sweden*), J.-A. Sauvaud (*France*), V. Sergeev (*Russia*),  
H. Spence (*USA*), M. Thomsen (*USA*), L. Zelenyi (*Russia*)  
and M. Scholer (*Germany*)

August 2002

R. M. Winglee  
Editor