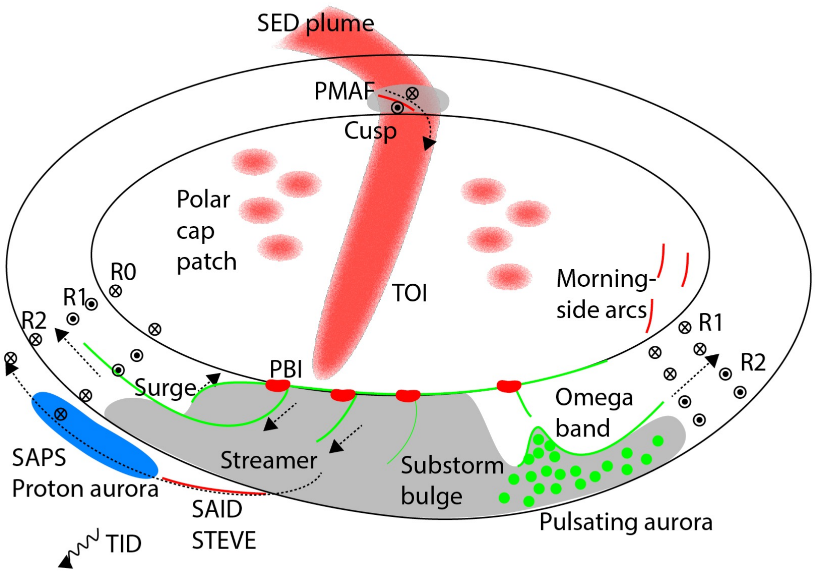
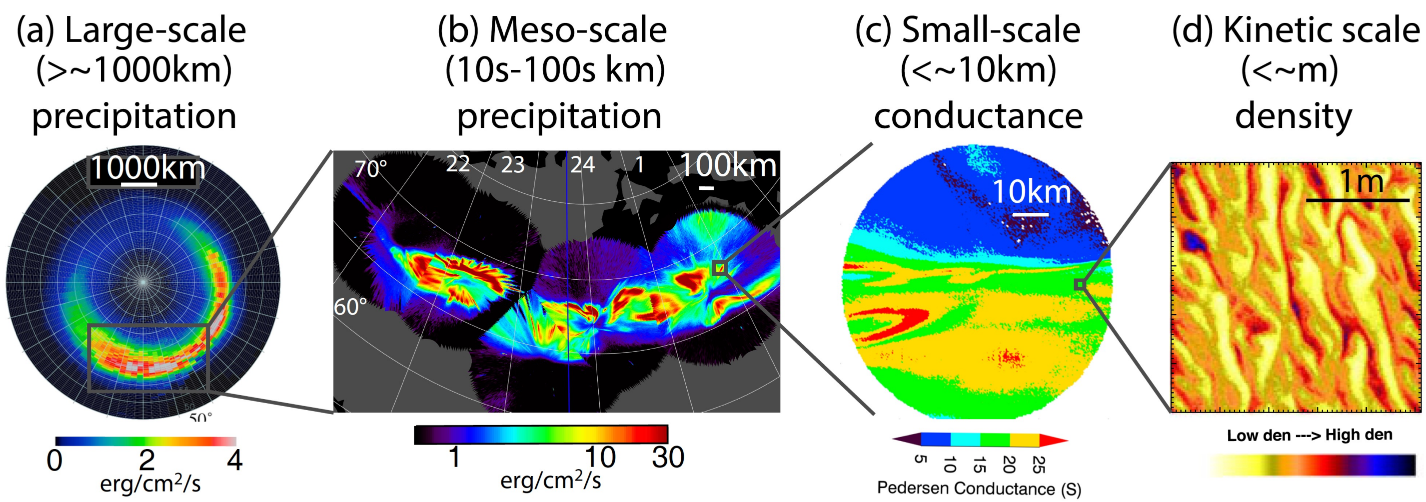
GC Report: Multi-scale I-T System Dynamics

Lead: Toshi Nishimura and Aaron Ridley

Objectives

- Understanding properties of I-T structures across scales, and their impact on the global system
- Quantifying their relation to forcing from the magnetosphere and atmosphere.
- Advancing capability for specifying multi-scale processes.





Nishimura, **Y.**, Y. Deng, L. R. Lyons, R. M. McGranaghan, M. D. Zettergren (2021), Multi-scale dynamics in the high-latitude ionosphere, AGU Monograph, doi: 10.1002/9781119815617.ch3.

Sessions in CEDAR 2020

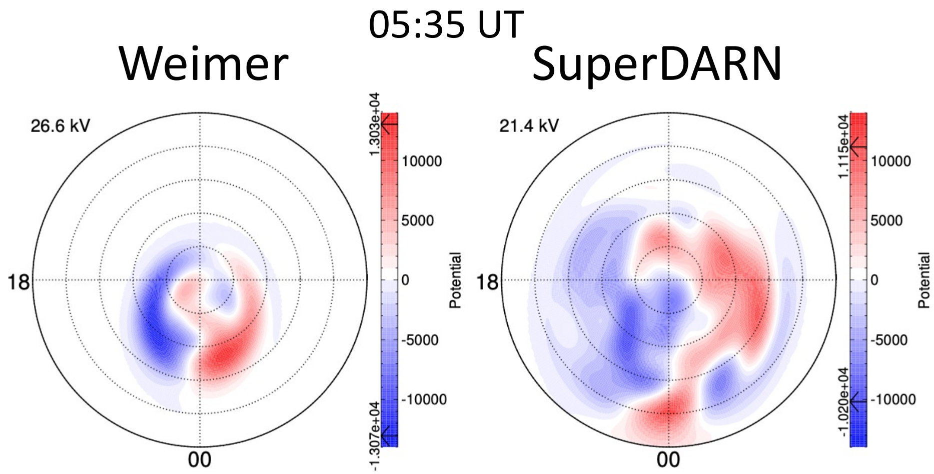
We invited 5 speakers to hear recent advances in observation and modeling of multi-scale processes. Each talk was followed by a long discussion time. Three short talks gave status reports. The session had strong participation (>140 attendees) and active discussions on the results and challenges. Selected results are summarized in the subsequent slides.

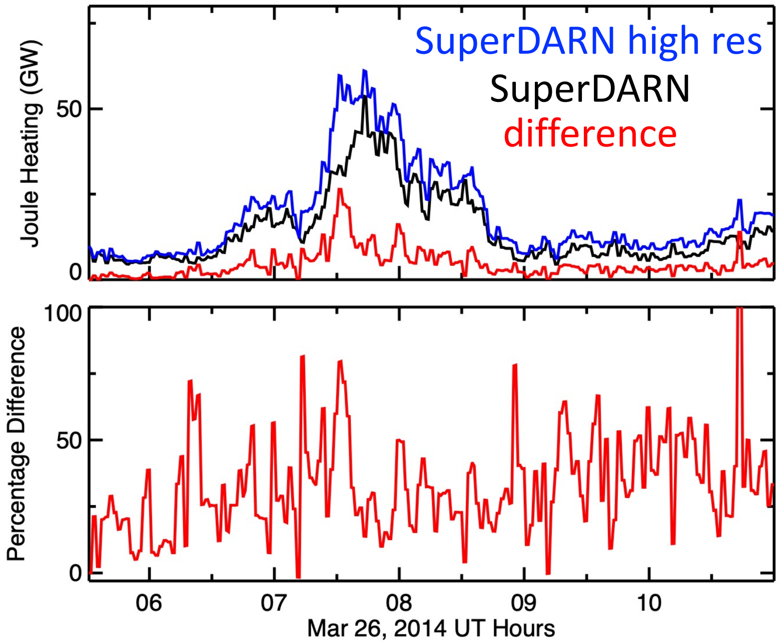
Yue Deng	GITM multi-scale simulation
Andres Spicher	Cusp rocket experiment of density structures
Xian Lu	Simulation of I-T responses to St. Patrick’s Day Storm
Leslie Lamarche	Polar cap patch instability observations and modeling
Doga Ozturk	GITM simulations with High-latitude Input (HIME)
Yu Hong	Hemispheric asymmetries of I-T system with GITM
Dong Lin	Diffuse Auroral Precipitation Effects on Convection
William Bristow	High-resolution SuperDARN observations

GITM Simulations Driven by Different Potential Patterns

Yue Deng et al.

Electric potential distribution

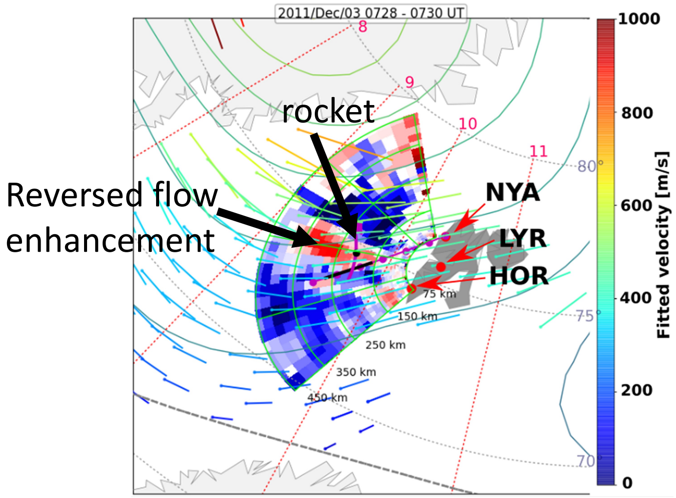


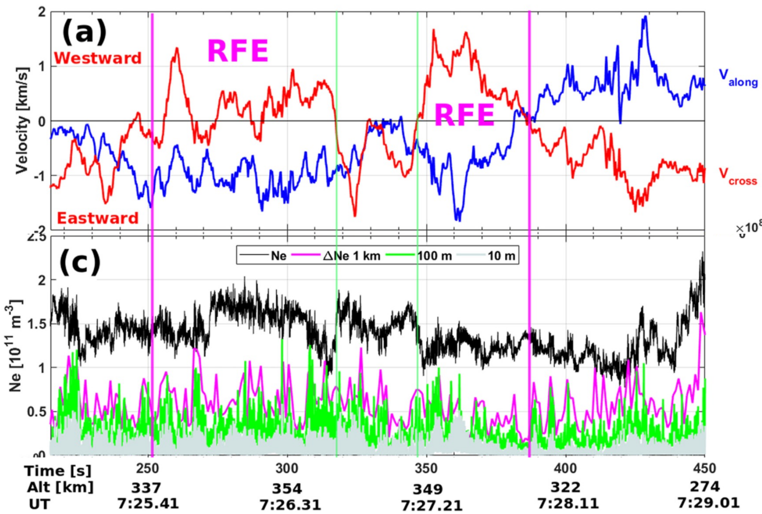


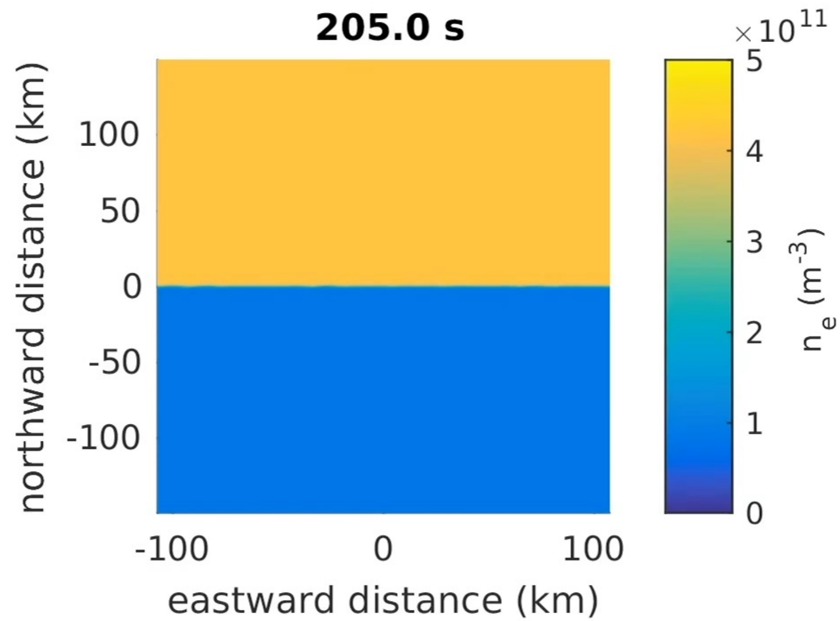
- Drive GITM with Bristow's high-resolution SuperDARN convection maps.
- Regional Joule heating with (blue) and without (black) the high-resolution SuperDARN potential, and their difference (red)
- Regional Joule heating increases ~30% on average due to localized fast flows.

Cusp rocket experiment of density structures

Andres Spicher et al.





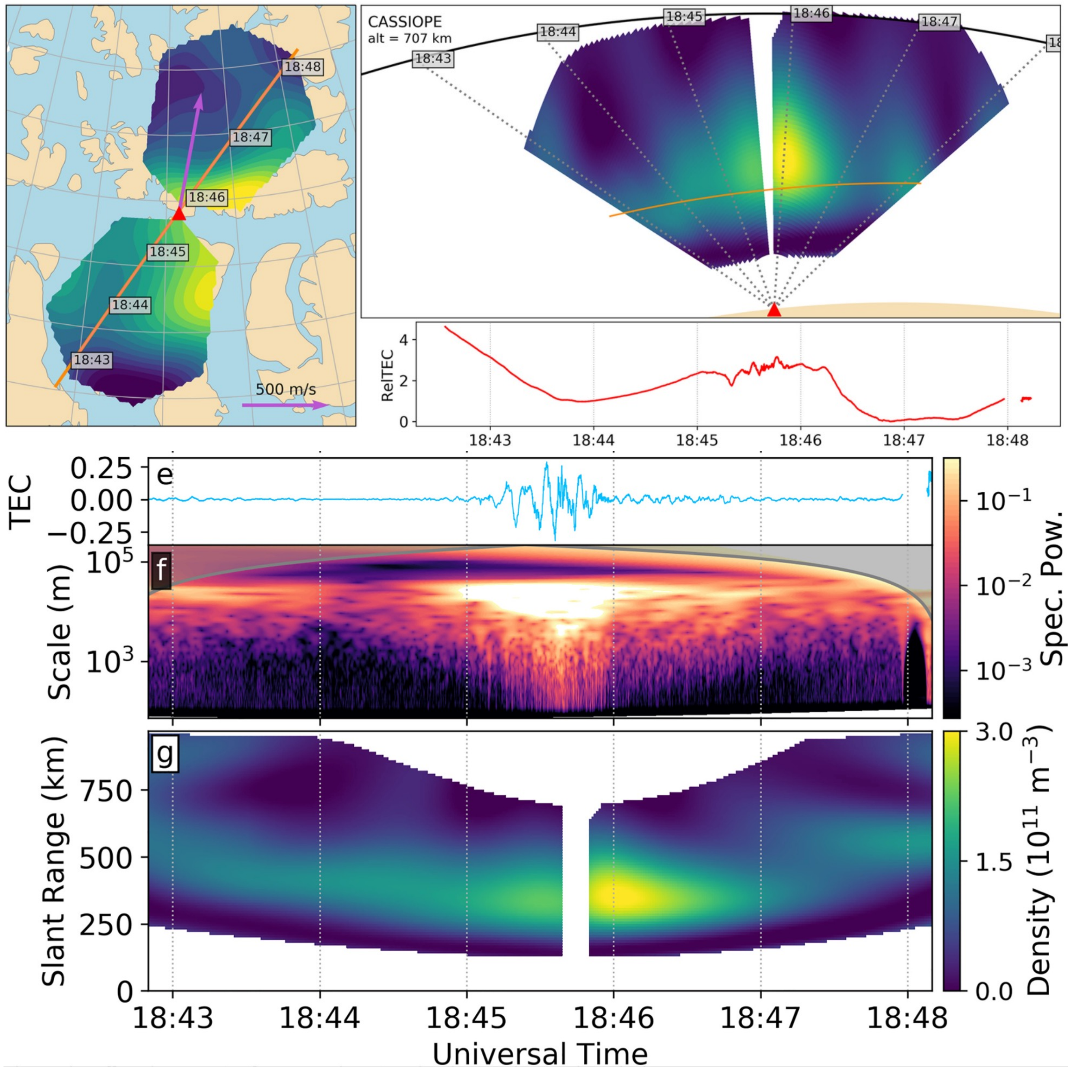


[Jin et al., 2019; Ivarsen et al., 2021]

ICI-3 rocket and radar observations of flow channels and density irregularities in the cusp. The GEMINI simulation showed that K-H instability explains the density irregularities.

Polar Cap Patch Instability Observations and Modeling

Leslie Lamarche et al.



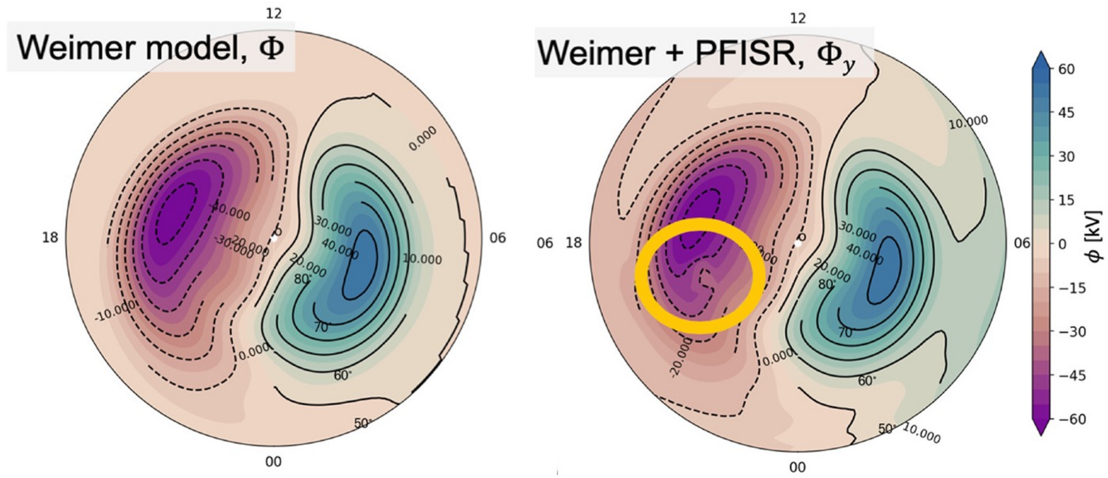
[Lamarche et al., 2020]

RISR, e-POP and radio receiver conjunction during a polar cap patch.
Density irregularities were developed at the trailing edge.
Gradient drift instability is suggested.

A New Framework to Incorporate High-Latitude Input for Mesoscale Electrodynamics

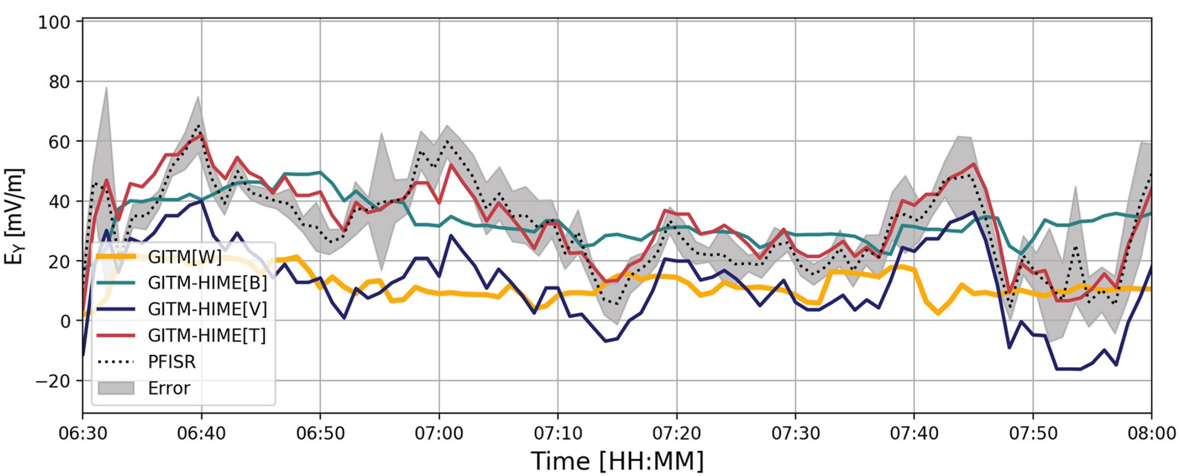
Doga Ozturk et al.

Default Input HIME



A new model was developed using PFISR to resolve dynamic electric field variability.

Energy deposited by HIME-driven simulations was locally larger by approximately an order of magnitude compared to the empirical model-driven results.



[Ozturk et al., 2020]

2020 AGU Fall Meeting session

Magnetosphere-Ionosphere-Thermosphere Coupling during Storms and Substorms

Toshi Nishimura, Yue Deng, Astrid Maute, Larry Lyons

16 oral talks (SA024, SA025)

Jesper	Gjerloev	Delores	Knipp
Robert	Pfaff	Daniel	Welling
Kazuo	Shiokawa	Robert	Strangeway
Jun	Liang	Cheng	Sheng
Dong	Lin	Qingyu	Zhu
Ercha	Aa	John	Meriwether
Shunrong	Zhang	Stephen	Kaeppler
Yun-Ju	Chen	Daniel	Billett

21 posters (SA021)

Fei	Zhang	Fatemeh	Bagheri	John	Coxon
Kiyoka	Murase	Zihan	Wang	Luke	Oberhagemann
Yudai	Inaba	Sneha	Yadav	Yan	Song
Austin	Brenner	Anna	DeJong	Yuto	Yano
Yakov	Dimant	Pauline	Dredger	Mayowa	Adewuyi
Robert	Gillies	Sumanjit	Chakraborty	Shin-ichiro	Oyama
Marcus	Pedersen	Joseph	Eggington	Valerie	Svaldi

2021 AGU Fall Meeting session

SA015. Magnetosphere-Ionosphere-Thermosphere Coupling during Storms and Substorms

Toshi Nishimura, Yue Deng, Astrid Maute, Larry Lyons

Review Book: Multi-Scale Coupling and Energy Transfer in the M-I-T System

Editors: Toshi Nishimura, Yue Deng,
Olga Verkhoglyadova, and Shunrong Zhang

ELSEVIER

We appreciate all authors who have dedicated their time to write the chapters.
All chapters were delivered to Elsevier in May 2021. The publication is expected next year.

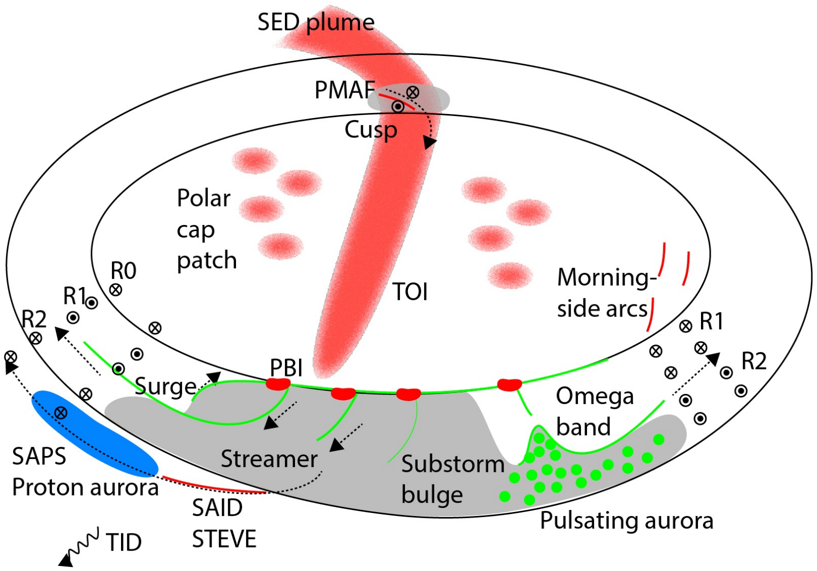
1. **Multi-scale processes in the M-I-T system**
   Y. Nishimura, Y. Deng, Q. Zhu, C. Lin, M. Jin, C. Liu, C. Sheng, A. Glocer
2. **Auroral structures: Revealing the Importance of Meso-Scale M-I Coupling**
   L. Lyons, B. Gallardo-Lacourt, Y. Nishimura
3. **Density, scintillation, temperature and composition**
   G. Perry, L. Goodwin, K. Deshpande, M. Zettergren, A. Spicher, L. Lamarche, M. Hirsch, M. Redden, S. Zhang, E. Aa
4. **Energetic particle dynamics, precipitation and conductivity**
   C. Gabrielse, S. Kaeppler, G. Lu, C. Wang, Y. Yu
5. **Electromagnetic energy input and dissipation**
   S. Kaeppler, D. Knipp, O. Verkhoglyadova, L. Kilcommons, W. Zhan
6. **Waves, Turbulence, and Kinetic Processes**
   M. Young, W. Longley, M. Oppenheim, Y. Dimant, X. Fang, V. Pilipenko, M. Engebretson, M. Hartinger, E. Fedorov, S. Coyle
7. **Ionosphere-thermosphere interaction**
   J. Lei, T. Dang, H. Liu, S. England, S. Zhang, H. Kil, W. Lee, L. Paxton

ISSI team on Multi-Scale M-I-T Interaction

Toshi Nishimura, Yue Deng, Shunrong Zhang, Qinghe Zhang, Jiuhou Lei, Kjellmar Oksavik, Eelco Doornbos, Matt Zettergren, Simon Wing, P. Jayachandran, Mingwu Jin, Chao Xiong, Qingyu Zhu, Sebastijan Mrak, and postdocs and students

Goals and objectives

- Quantify the role of multi-scale processes in the M-I-T system and advance community's understanding of how multi-scale structures form and evolve.
- Conduct international collaborative projects of observation and modeling of multi-scale processes.



This year's sessions in CEDAR

10-12am MDT, Wednesday June 23
Multi-scale I-T Simulation

Aaron Ridley	New model development on GITM
Yue Deng	Ion-neutral coupling at different latitudes
Doga Ozturk	Small-scale GITM simulations
Tzu-Wei Fang	Forecasting Multi-scale Space Weather in the Upper Atmosphere
Ryan McGranaghan	Multiscale geospace particle transfer by and machine learning
Erdal Yigit	Small-scale gravity waves

1-3pm MDT, Wednesday June 23
Multi-scale I-T observation and data assimilation

Tomoko Matsuo	Data assimilation with meso-scale precipitation
Richard Linares	Data assimilation and uncertainty quantification of the thermosphere
Bill Bristow	Updates on high resolution SuperDARN convection map
Larry Lyons	Interplay between meso-scale aurora and flow
Leslie Lamarche	Multiscale Scintillation in the Polar Cap
Qingyu Zhu	Impact of soft electron precipitation on the thermosphere