

Geospace Dynamics Constellation (GDC) Interdisciplinary Scientists (IDS)

Study of multi-scale forcing impact on the I-T system:
Support from Observations and Physics Models (SOPHIE)
(2022-2029)

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University of Colorado
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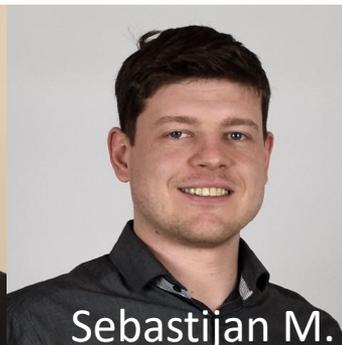
Yue D.



Christine G.



Mingwu J.



Sebastijan M.



Ramon L.



Cheng S.



Daniel W.



Shunrong Z.



Simon W.

2. Objectives:

Proposed IDS-specific tasks:

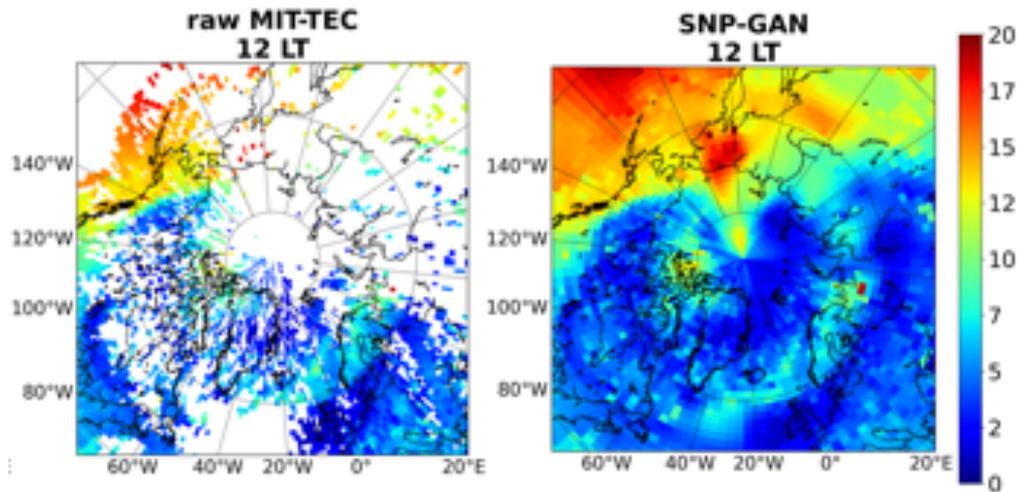
- **Development of analysis techniques and tools:** generate 2-D TEC map using machine learning, estimate neutral wind acceleration from observations, generate particle precipitation and local ion-convection maps from ground-based data, improve ISR ionospheric models.
- **Enhancements of GITM model:** upgrade grid, enhance forcing specification, include mesoscale; couple with ASHLEY, SWMF, and ground-based observations, enable transition models to operational use.

Proposed mission-specified tasks:

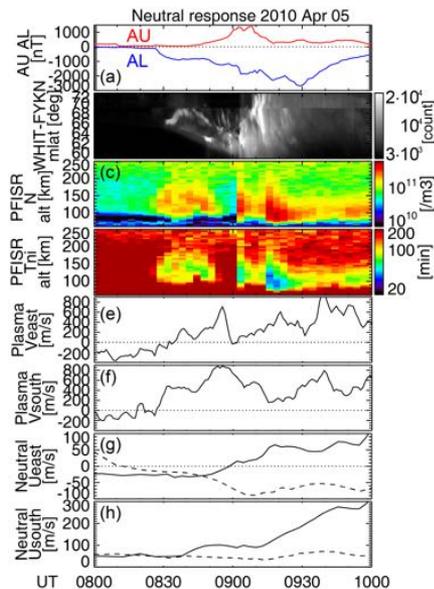
- **Refinement of the constellation configuration and mission requirements.**
 - Virtual satellites in GITM simulations
 - Specification of multi-scale forcing and I-T variations
- **Calibration, validation, and verification.**
 - Cal/Val via Incoherent Scatter Radars
 - Verification with ASI, SuperDARN, GNSS TEC, FPI, and other observations
- **Data products**
 - Joule heating & ionospheric conductance

3.1 Technical Approach: IDS-specific tasks

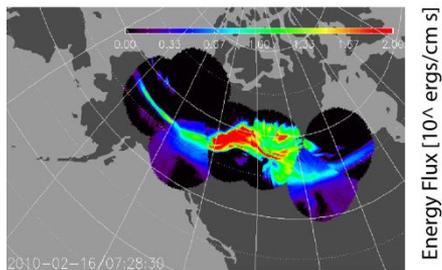
(1) Development of analysis techniques and tools:



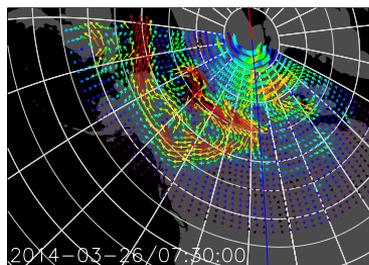
(a) 2-D TEC map reconstructed by SNP-GAN



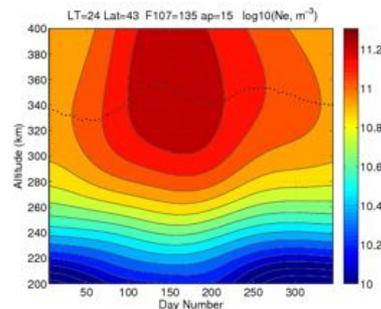
(b) Neutral-ion collision time scale



Energy Flux [10^8 ergs/cm s]



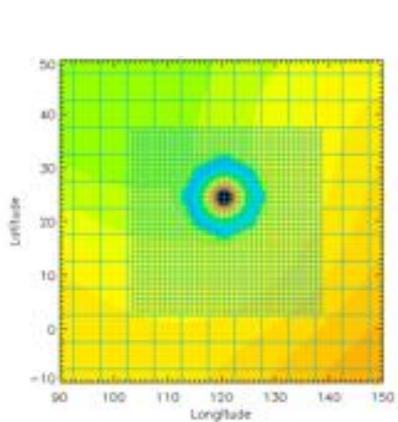
(c) Aurora flux from ASI (left) & SuperDARN high-reso ion flow (right)



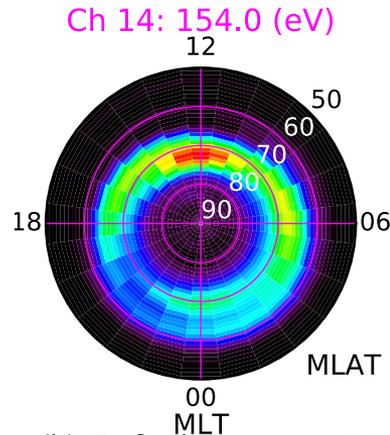
(d) ISRIM electron density

(2) Enhancements of GITM model:

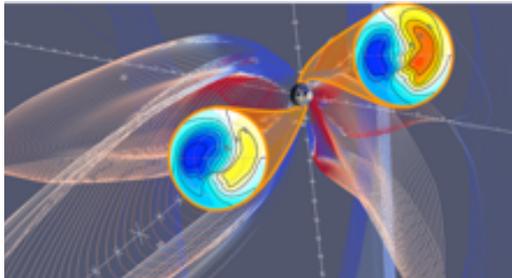
- upgrade simulation grid,
- include physical processes related mesoscale,
- couple with ASHLEY, MHD, and ground-based observations,
- enable transition models to operational use.



(a) Grid: GITM-R



(b) Soft electrons: ASHLEY



(c) Asymmetry:
MHD model

Log in

SOPHIE - UI80 - The University of Texas at Arlington

Log in

SOPHIE

SOPHIE

Support from Observations and Physical model (SOPHIE) for GDC

Observations:

Incoherent Scatter Radars (ISRs)

SuperDARN

All Sky Imagers (ASIs)

Global Navigation Satellite System (GNSS)

Models:

GITM

ASHLEY

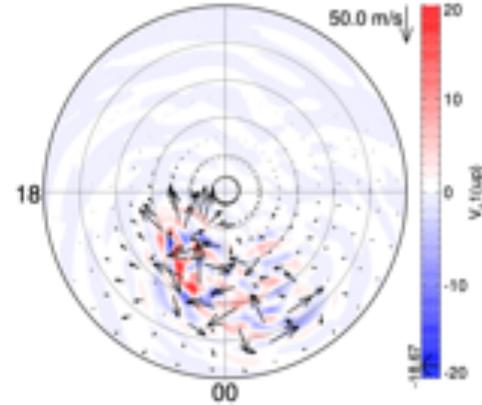
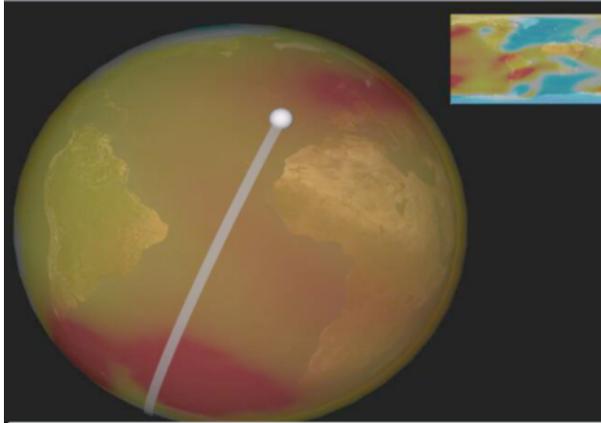
SNP-GAN

SWMF

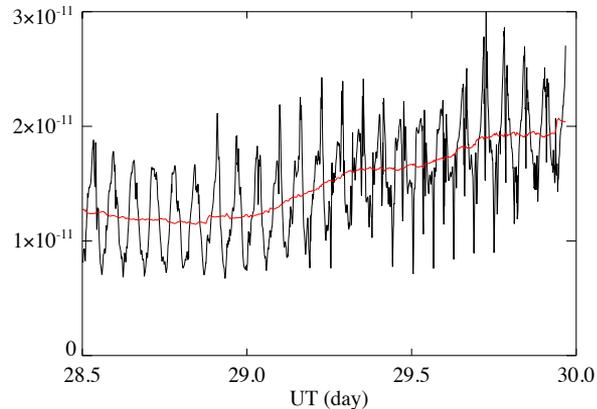
(d) Platform SOPHIE

4.2 Technical Approach: mission-specified tasks

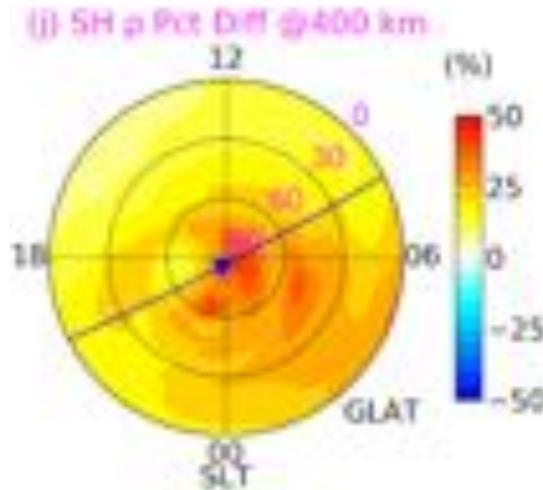
(1) Refinement of the constellation configuration and mission requirements.



(b) Impact of meso-scale ion convection



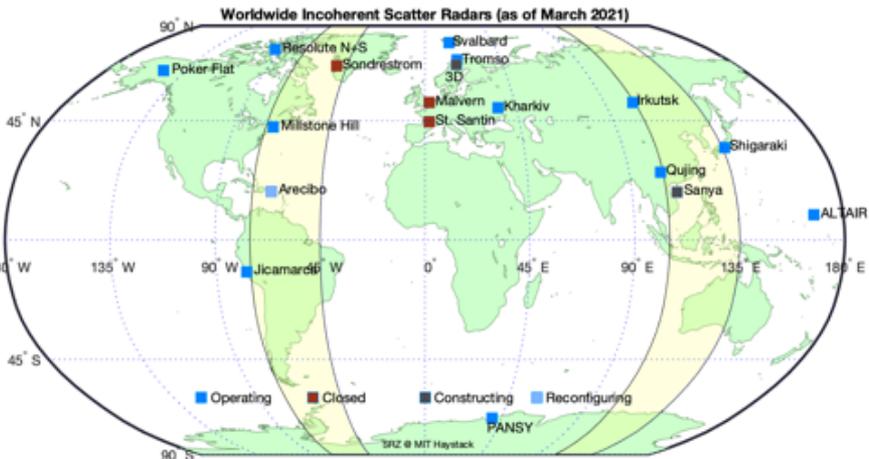
(a) Virtual satellites in GITM



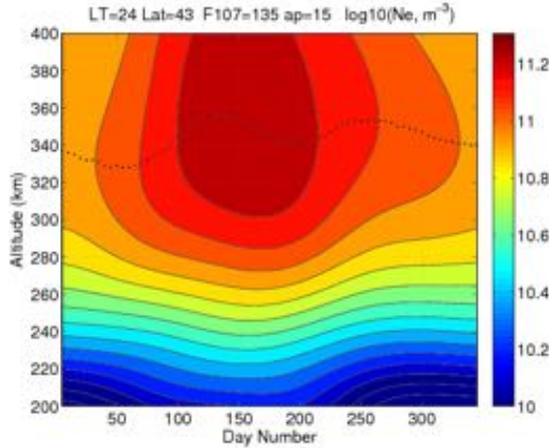
(c) Impact of large-scale forcing: soft electron

(2) Calibration, validation, and verification.

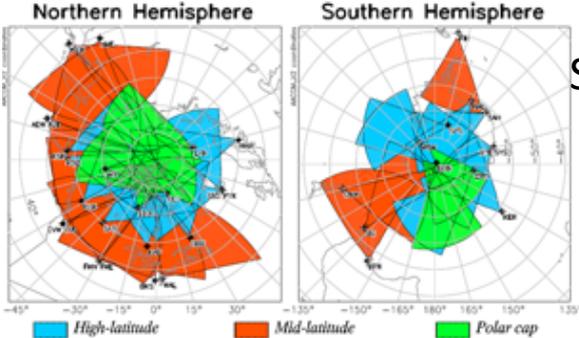
- Cal/Val via Incoherent Scatter Radars
- Verification with ASI, SuperDARN, GNSS TEC, FPI, and other observations



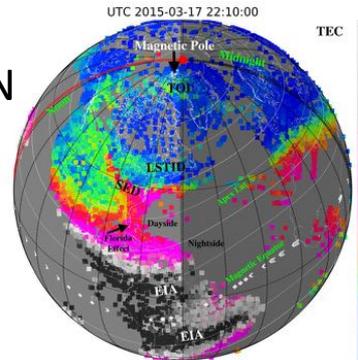
ISRs



ISRIM



SuperDARN



GNSS TEC

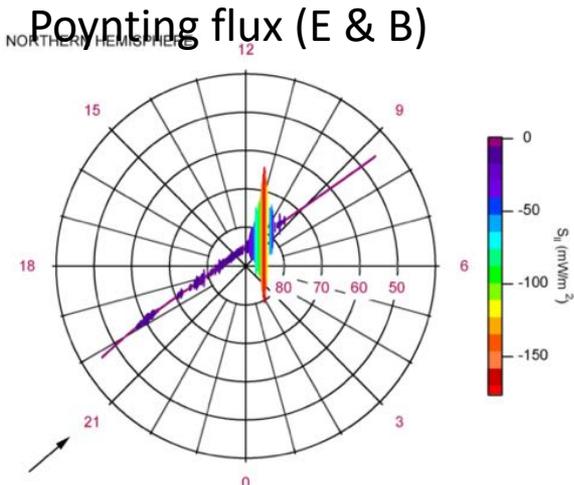


LEO satellites

(3) Data products

- Joule heating & ionospheric conductance

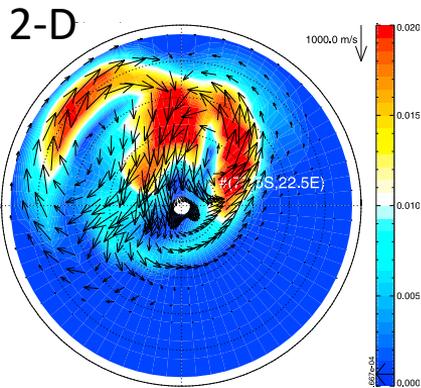
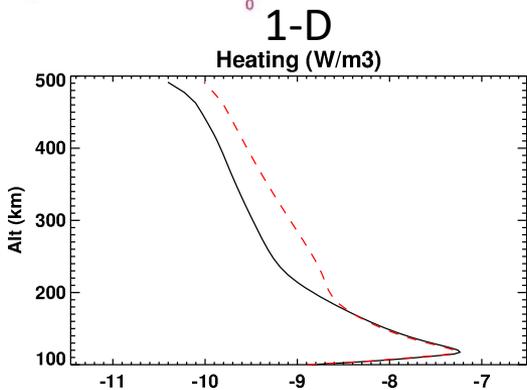
Observations:



Robinson Formulas (\bar{E} & Φ_E)

$$\Sigma_P = \frac{40\bar{E}}{16 + \bar{E}^2} \Phi_E^{1/2},$$
$$\frac{\Sigma_H}{\Sigma_P} = 0.45\bar{E}^{0.85}.$$

GITM simulations:



3-D or 4-D



SOPHIE-IDS team kickoff meeting in Oct. 2022