3D Auroral Current Closure Modeling using GEMINI

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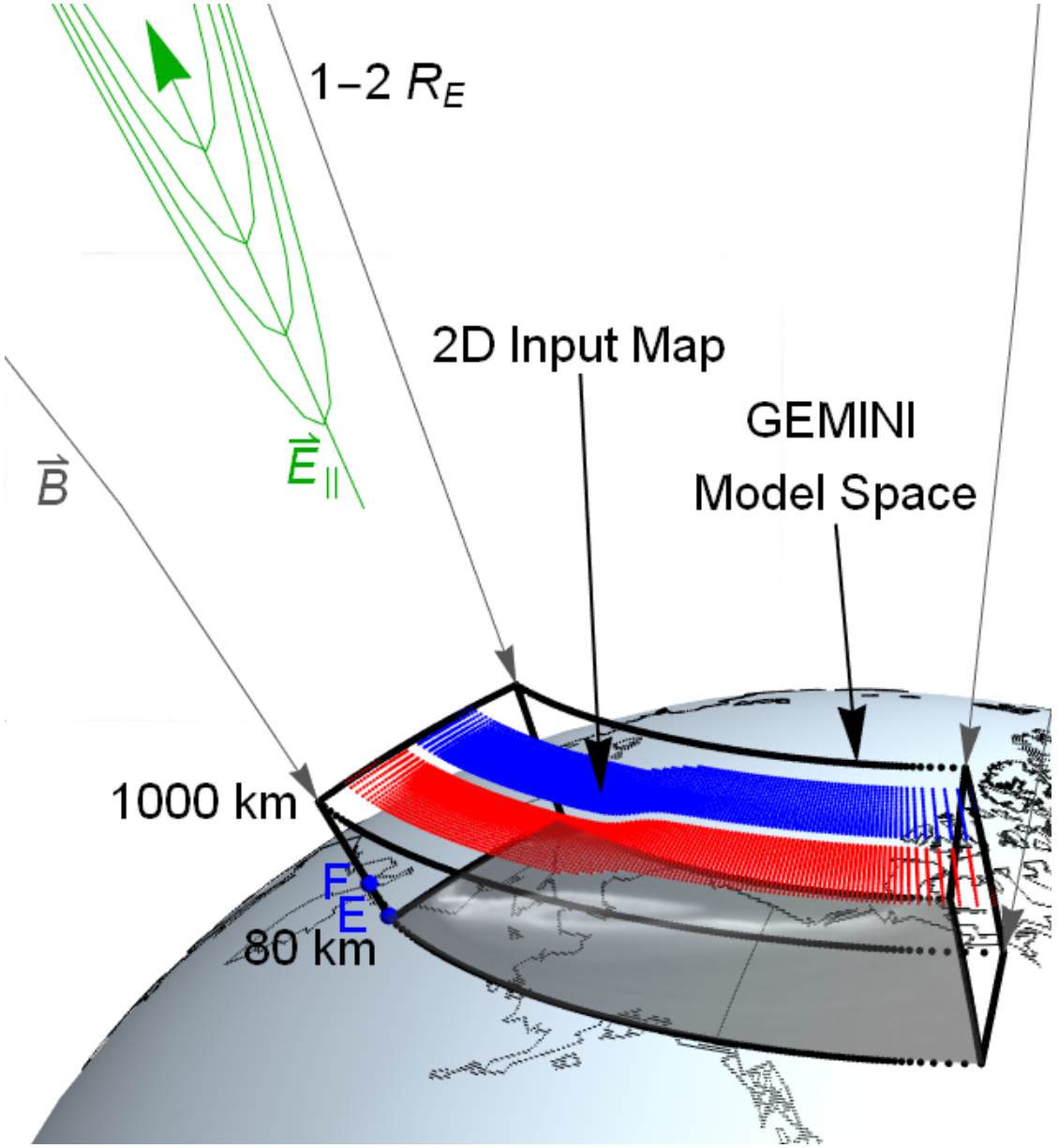
Context and Purpose

- **Model:** We're using GEMINI to model auroral current systems in 3D (github.com/gemini3d)
- **Model Type:** Multi-fluid, electrostatic with 2D+T B.C.'s

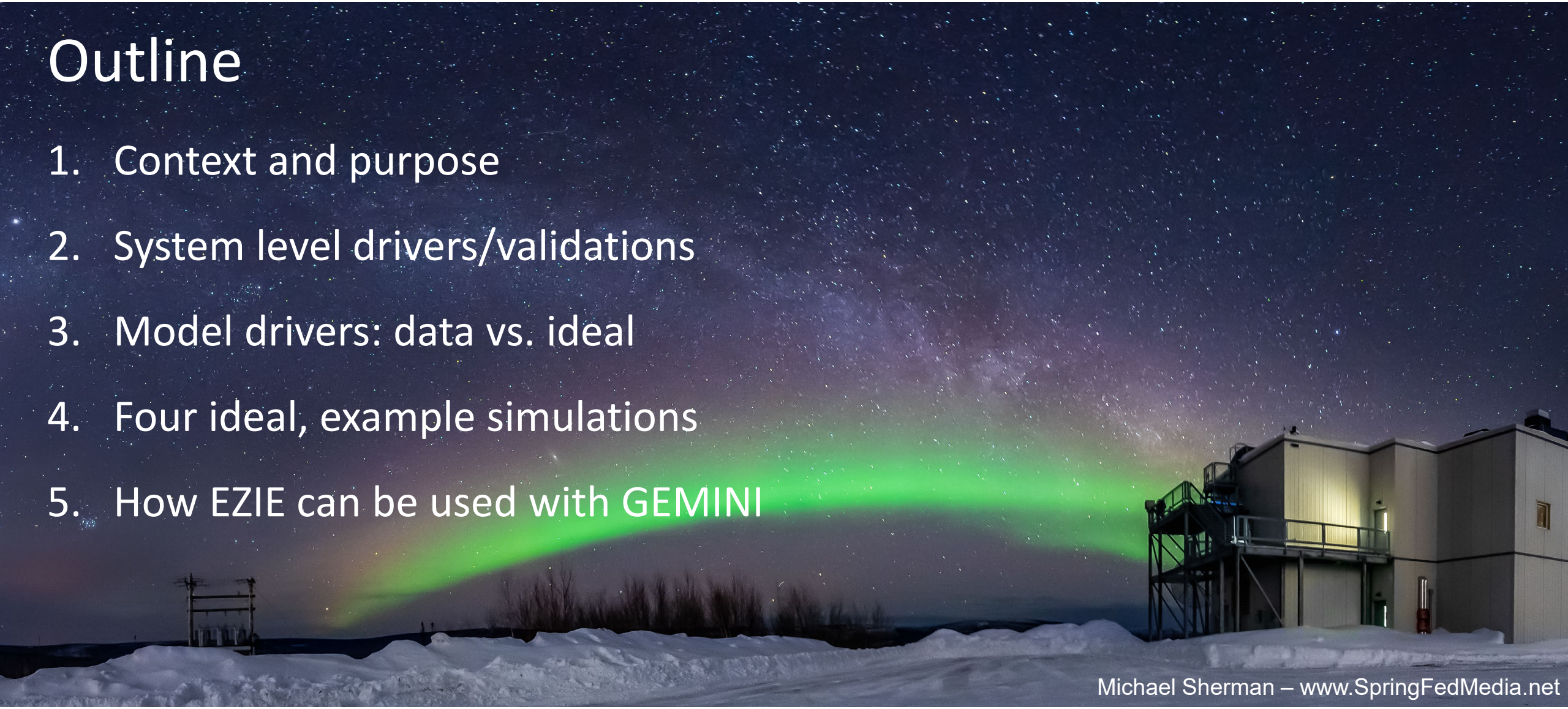
Solves c. c. in 3D: $-j_{\parallel} = \Sigma_P \nabla \cdot \mathbf{E} + \mathbf{E} \cdot \nabla \Sigma_P - (\mathbf{b} \times \mathbf{E}) \nabla \Sigma_H$

- **Scale:** Auroral latitudes and arc scale sizes at ionospheric altitudes
- **Model Drivers:** 2D topside maps of auroral precipitation parameters + maps of field-aligned current *or* plasma flow
- **Purpose:** What self-consistency constraints exist in creating a geophysically coherent set of F-region quasistatic auroral system drivers?



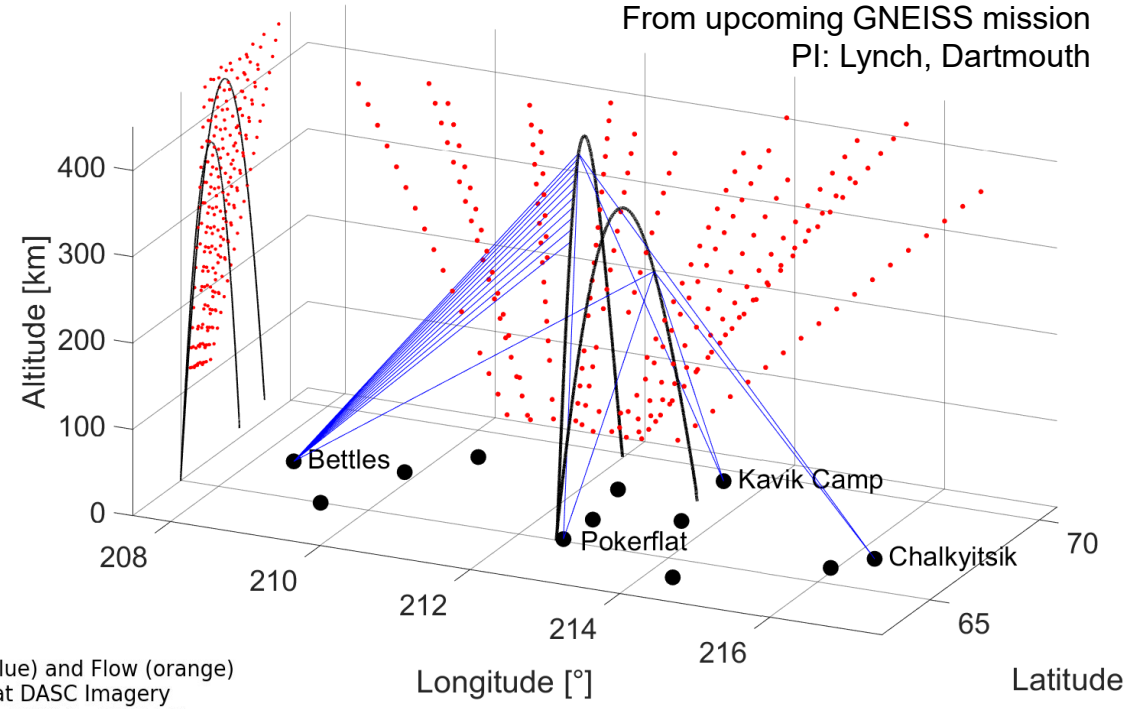
Outline

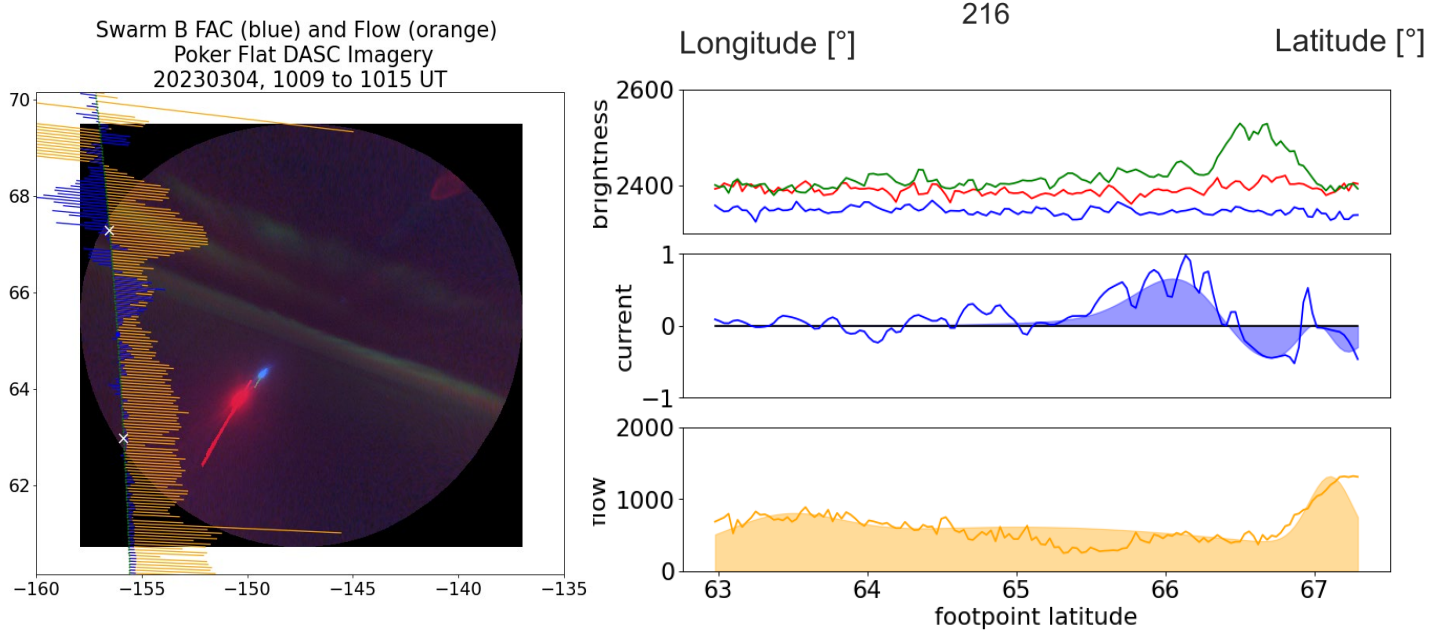
1. Context and purpose
2. System level drivers/validations
3. Model drivers: data vs. ideal
4. Four ideal, example simulations
5. How EZIE can be used with GEMINI



System Level Drivers/Validations

- GEMINI is a great tool, but we want to make sure we use it correctly!
- We need heterogeneous, data-inspired drivers and validators:
  - Rocket data: Isinglass (Dartmouth), GNEISS (Dartmouth)
  - Ground-based Imagery: DASC (UAF/GI), THEMIS-GBO (U Calgary)
  - Radar data: PFISR (UAF/GI), EISCAT
  - Neutral wind data: SDI (UAF/GI)
  - TEC data: Tomography or GPS
  - Spacecraft in-situ data: Swarm (ESA), EZIE?!



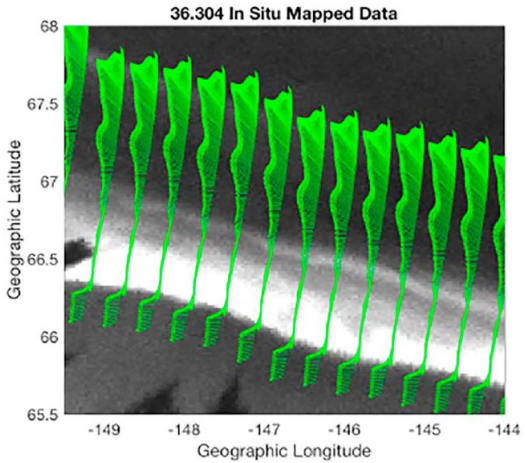


Graphic: A. Mule. Data: UAF/GI DASC (imagery) and ESA Swarm (flow/current)

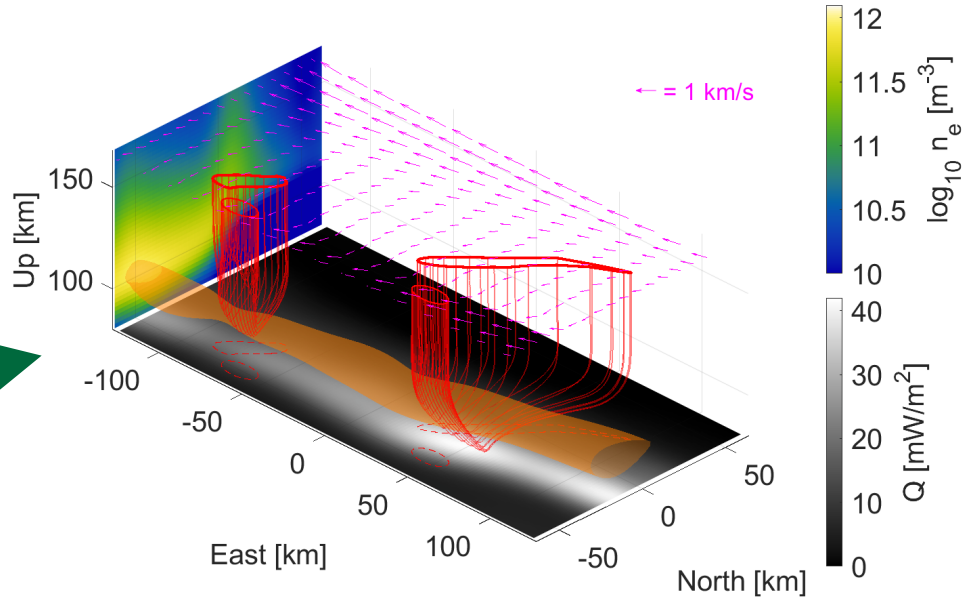
Model Drivers: Data vs. Ideal

- What self-consistency constraints exist in creating a geophysically coherent set of F-region quasistatic auroral system drivers?
- Dissect complex, multi-parameter, 3D auroral arc systems
- How to explore parameter sensitivities
- Use ideal drivers

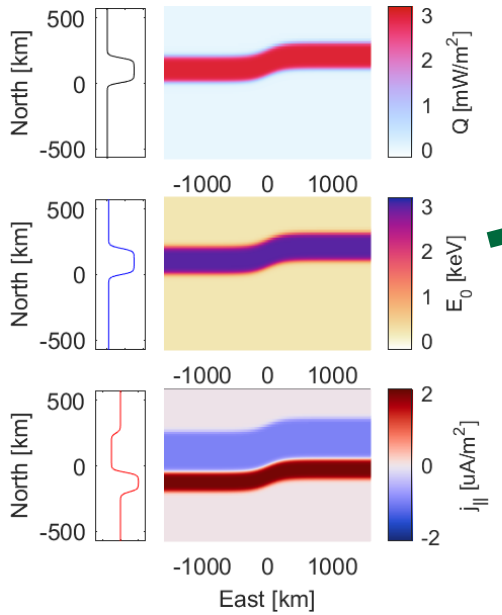
Data Driven

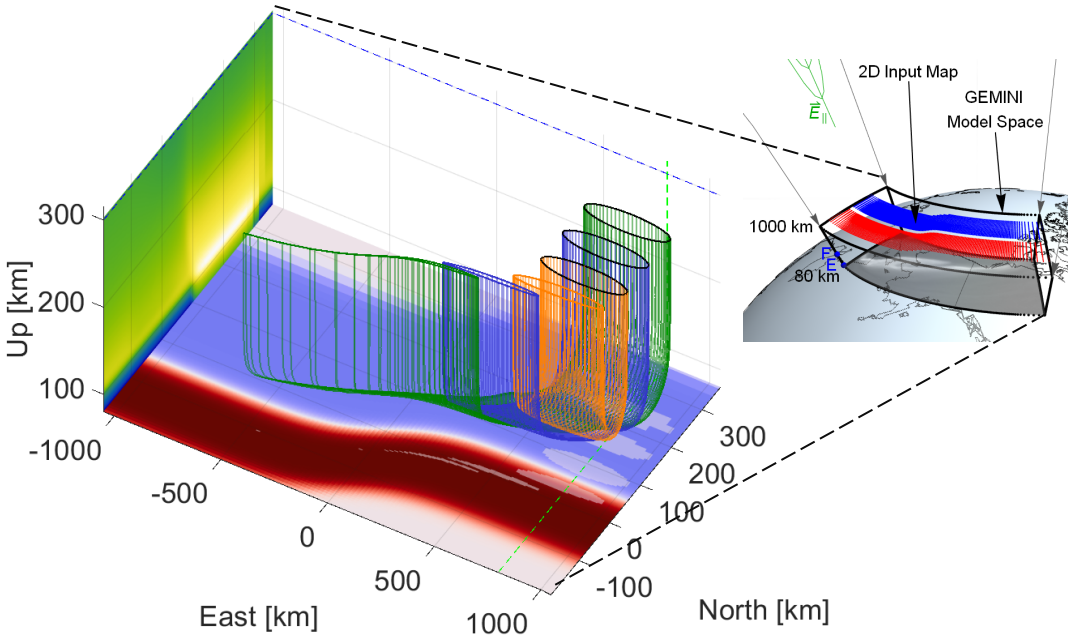


Clayton et al. 2019

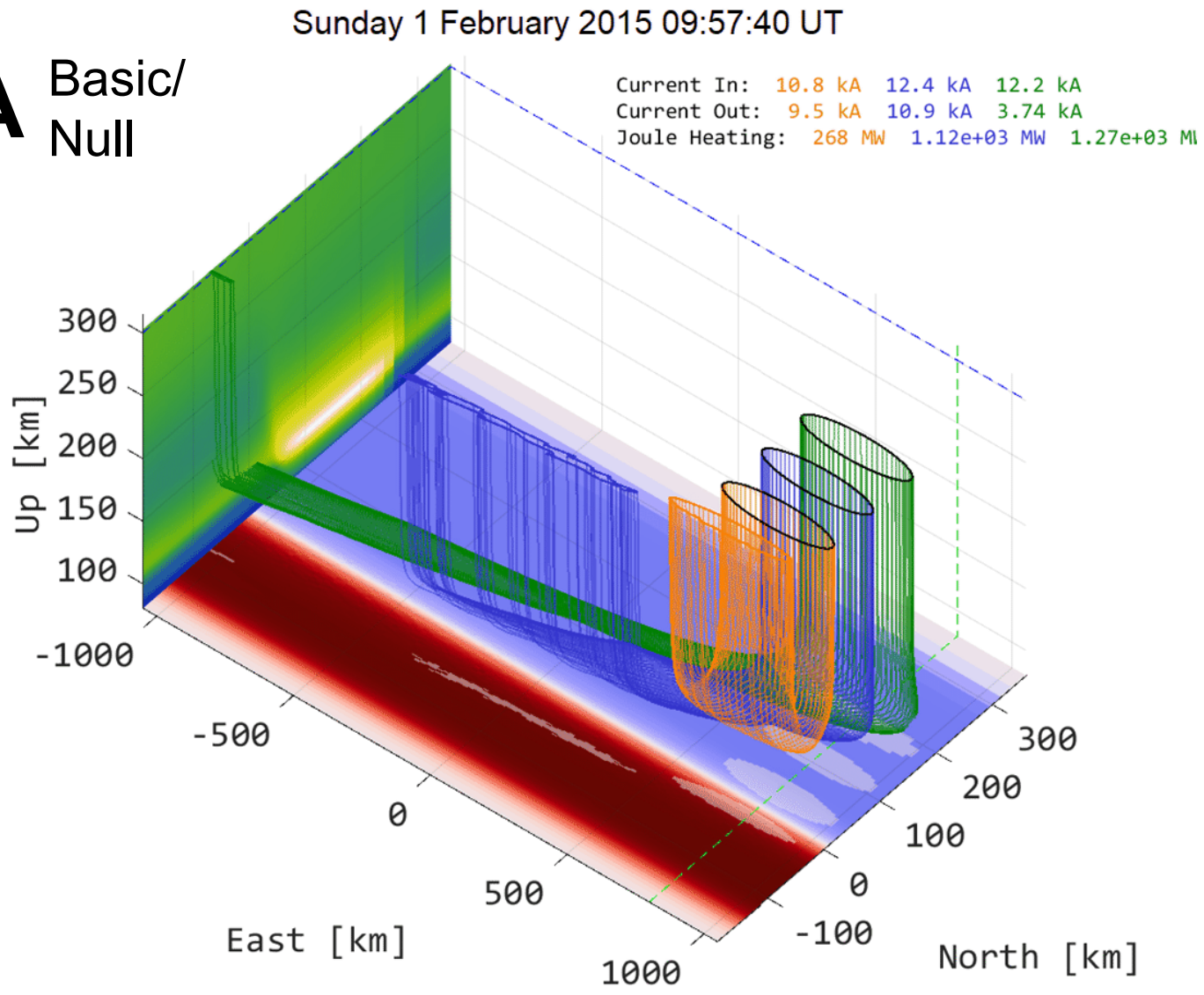


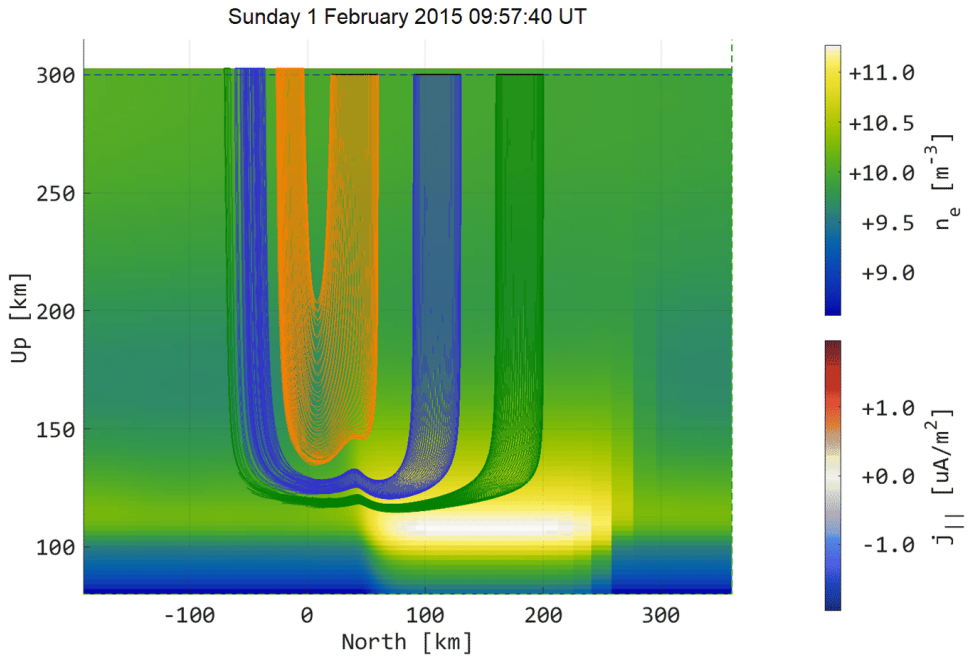
Physics Driven

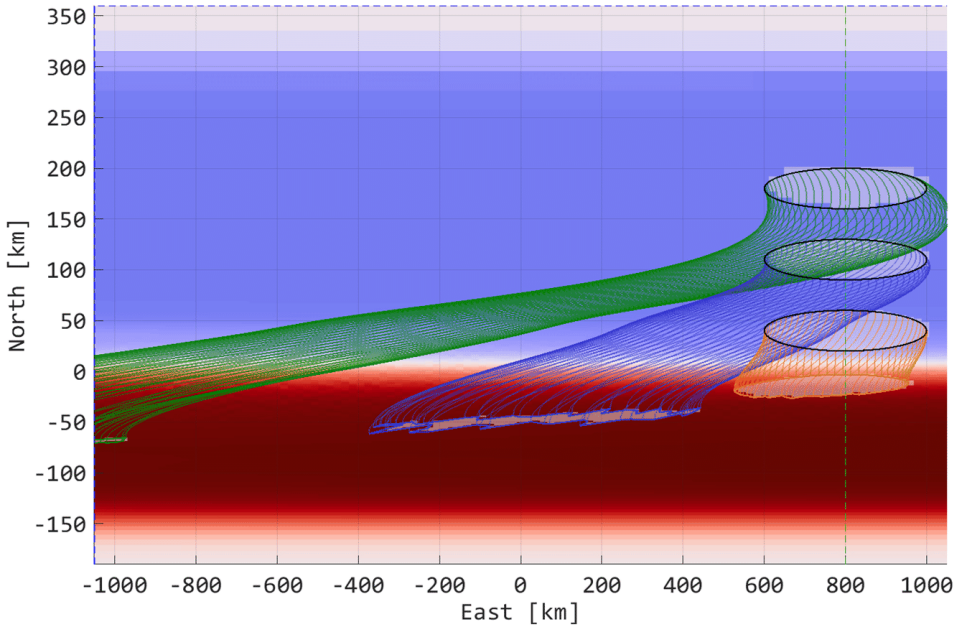




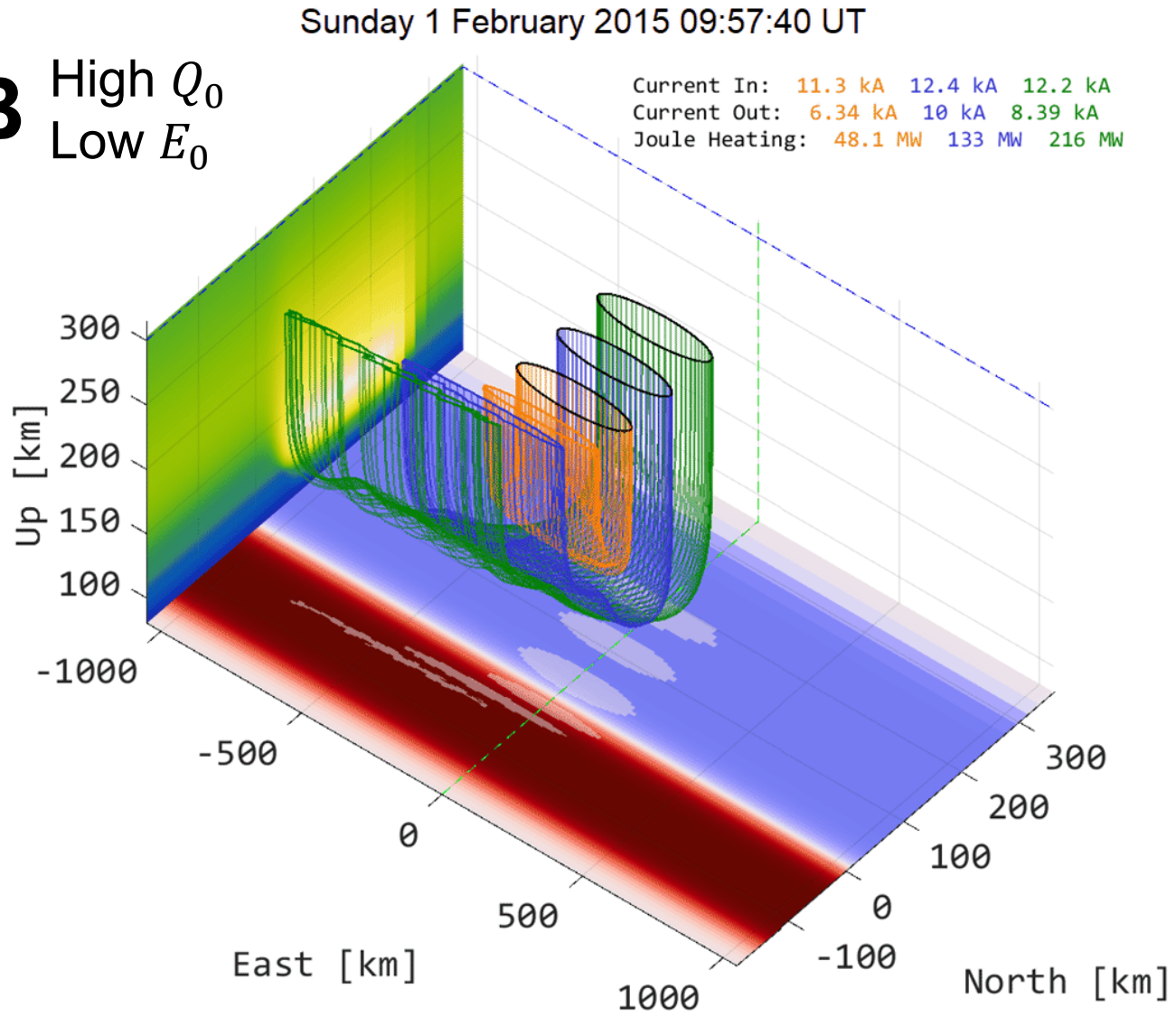
A Basic/ Null

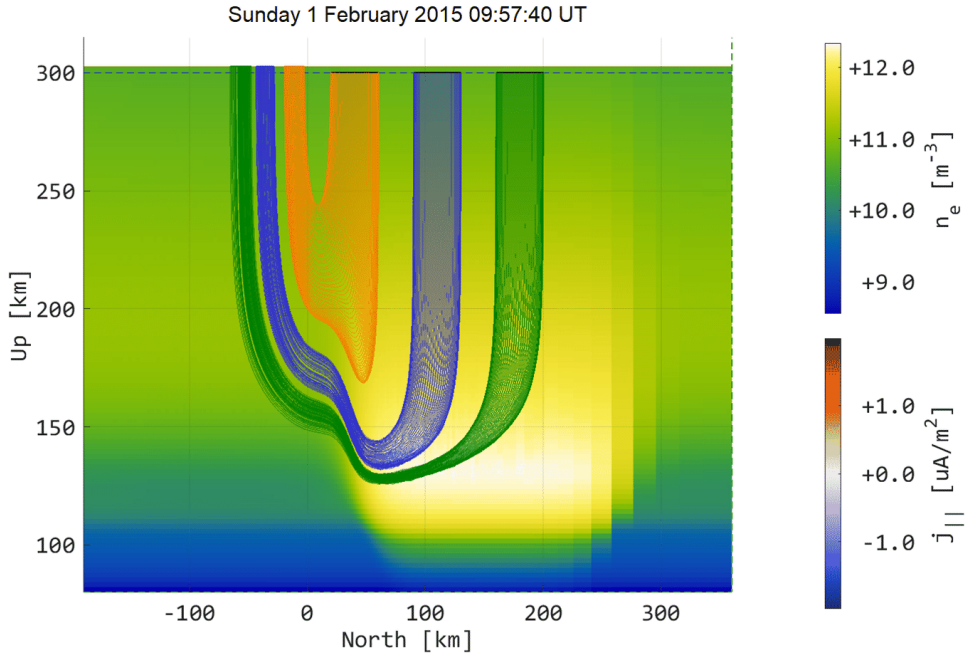

Sunday 1 February 2015 09:57:40 UT
Current In: 10.8 kA 12.4 kA 12.2 kA
Current Out: 9.5 kA 10.9 kA 3.74 kA
Joule Heating: 268 MW 1.12e+03 MW 1.27e+03 MW
Up [km]
East [km]
North [km]

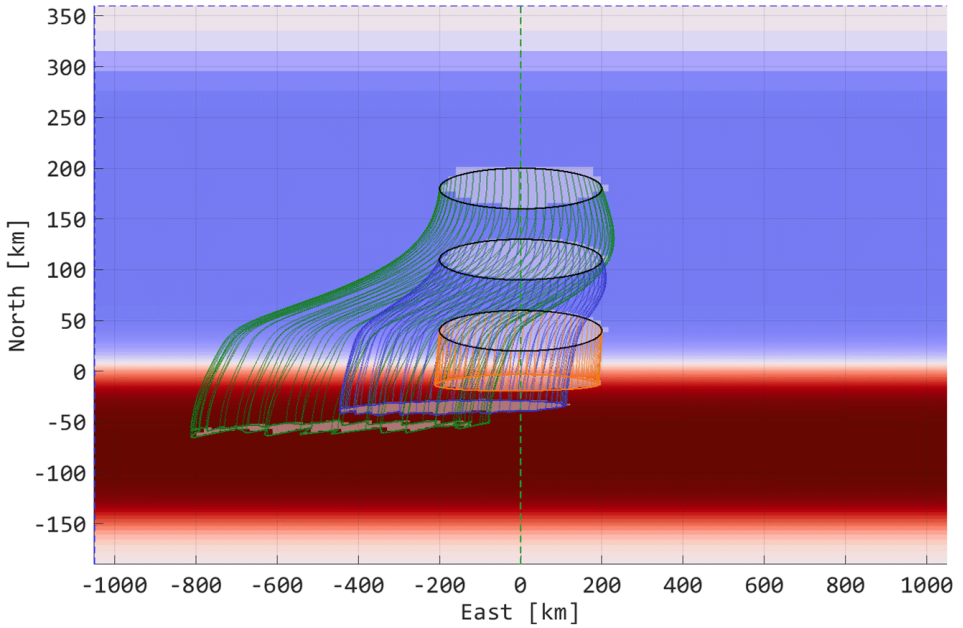

Sunday 1 February 2015 09:57:40 UT
Up [km]
North [km]
n_e [m^{-3}]
$j_{||}$ [uA/m^2]


North [km]
East [km]

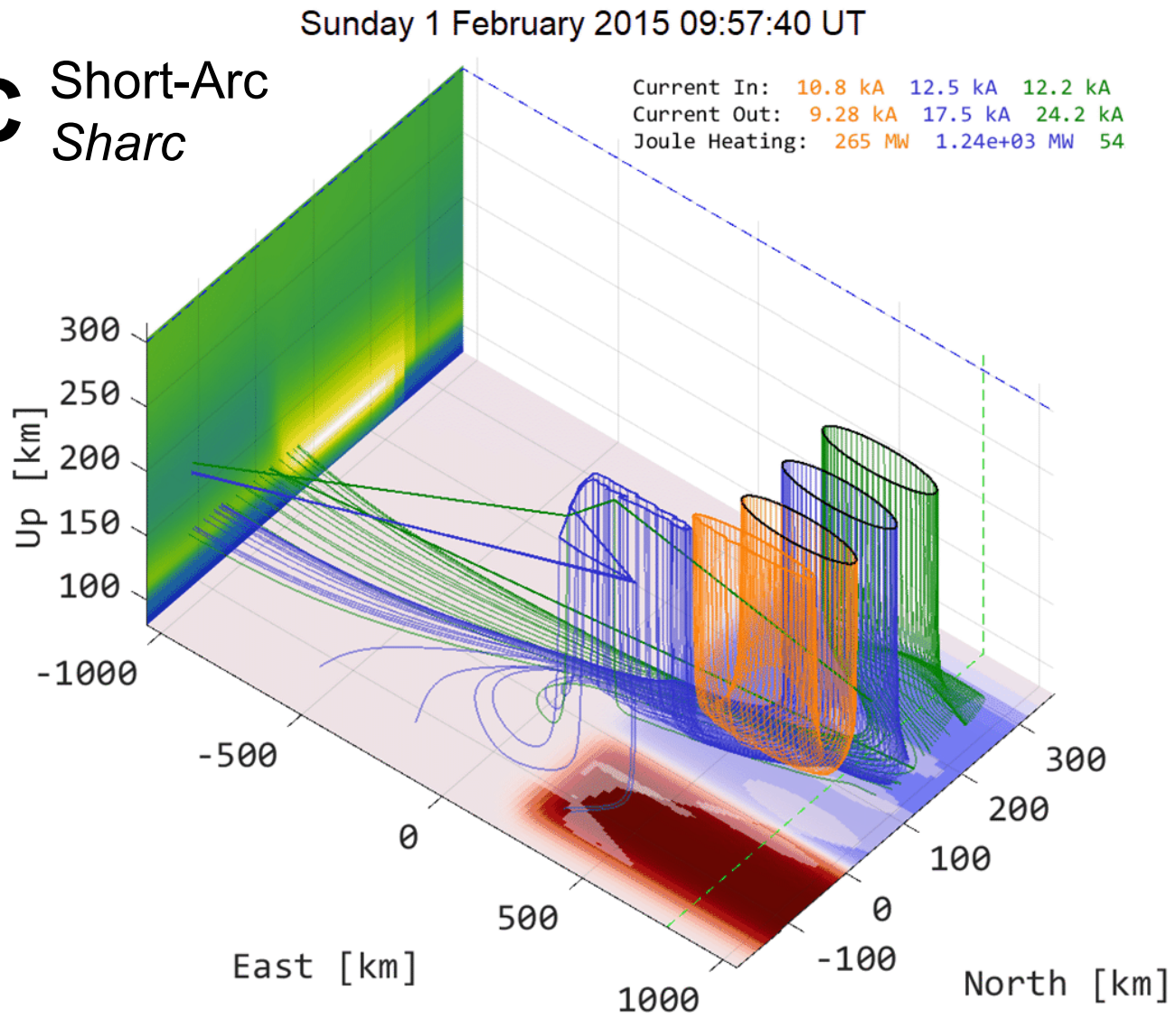
B High Q_0
Low E_0

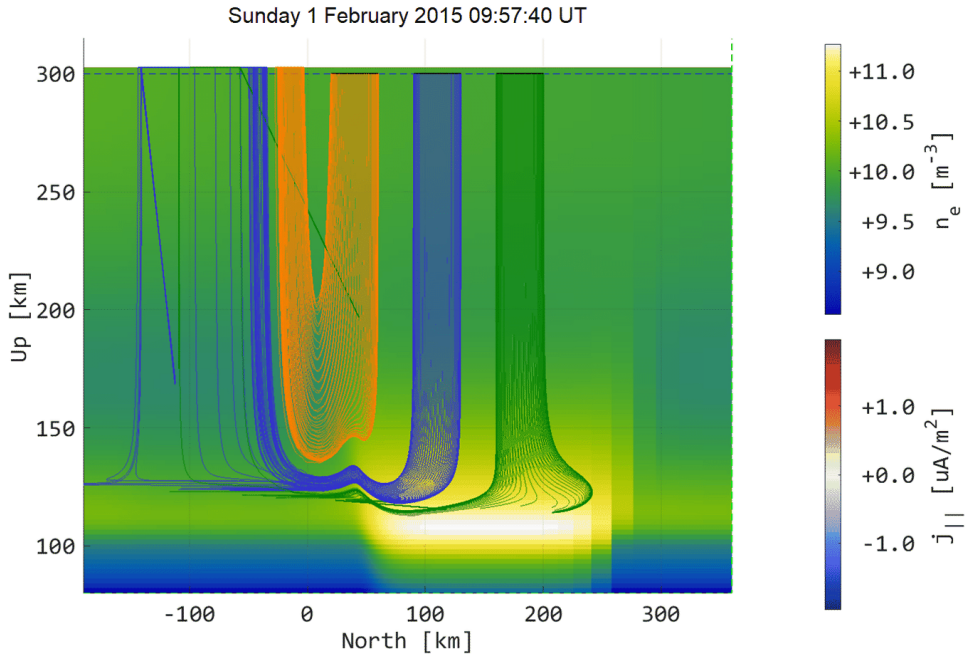


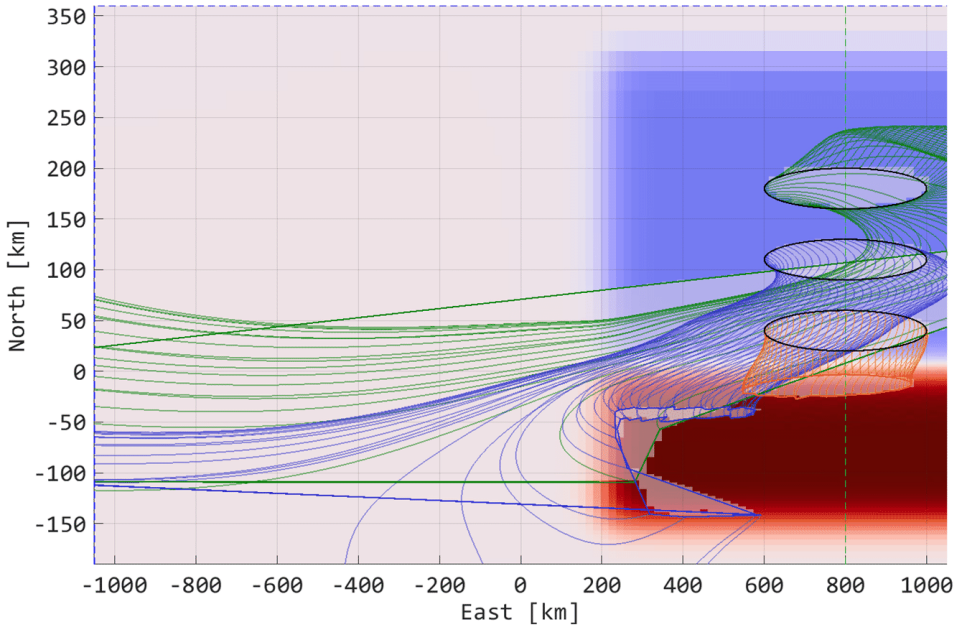


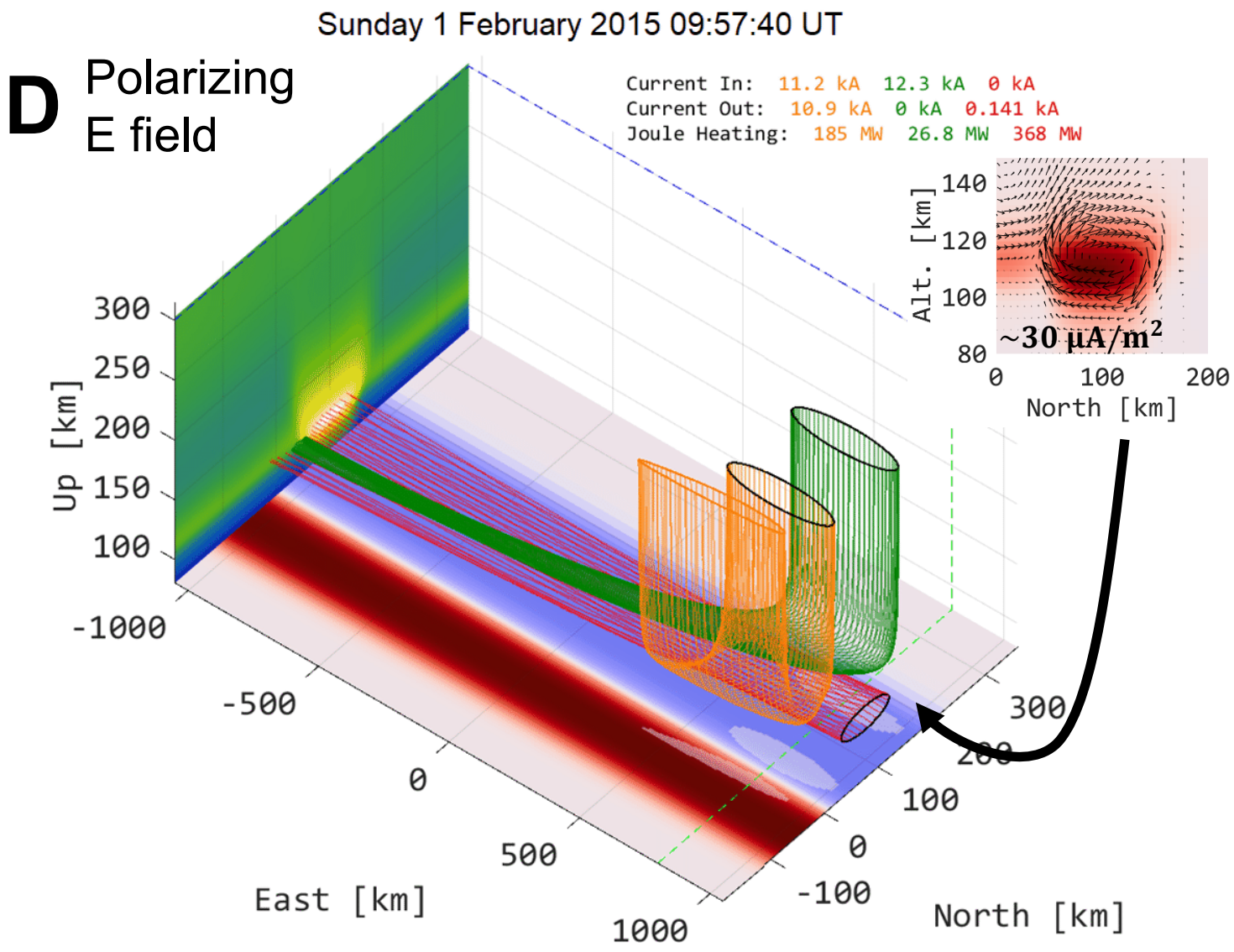


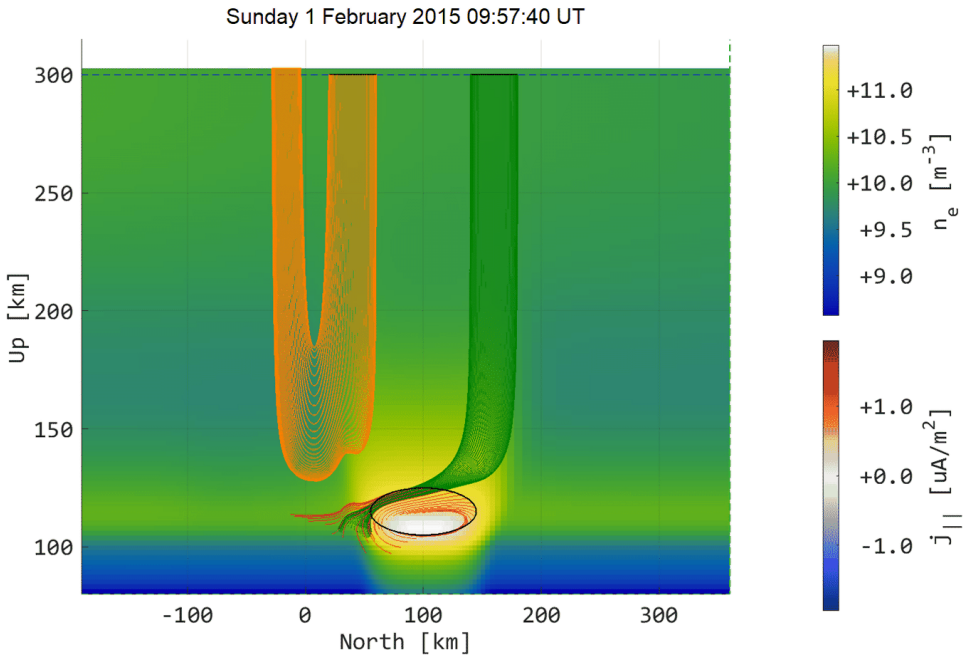
C Short-Arc *Sharc*

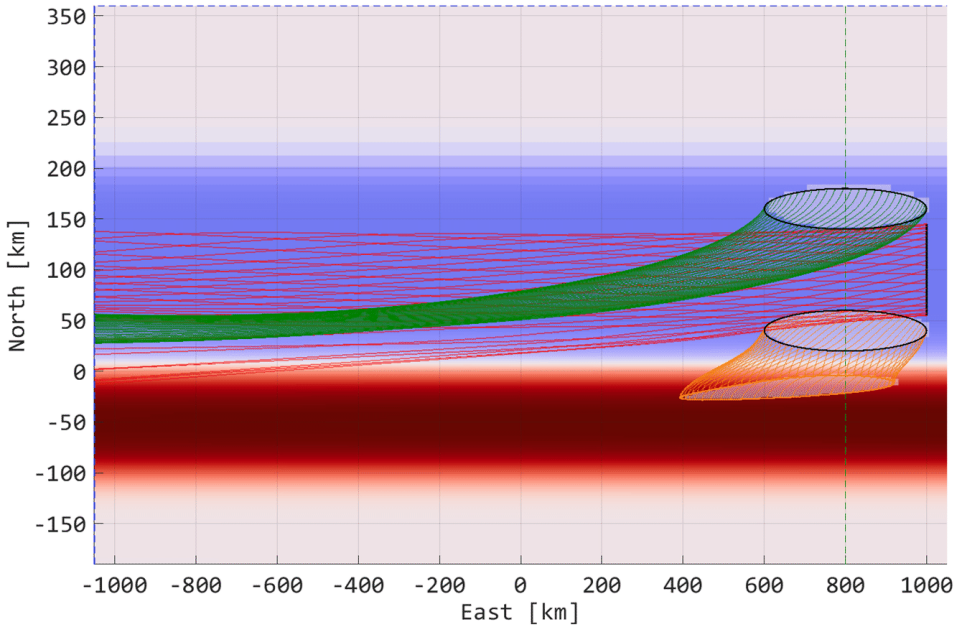












Simulation modelled after a 2D simulation by Mallinckrodt (1985)

How EZIE can be used with GEMINI

- Which simulation is geophysical?
- Is $\boldsymbol{j}_H$ from arc scale FAC closure resolvable from auroral electrojet currents?