GITM Simulations of High-Speed-Stream Events

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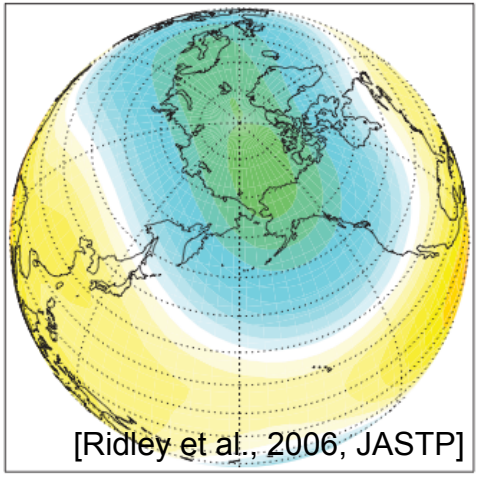
1. *JPL, California Institute of Technology*
2. *University of Michigan*

Outline

- Introduction and simulation set-up
- Simulated nitric oxide (NO) cooling Vs. TIMED/SABER measurement
- Simulated O/N_2 Vs. TIMED/GUVI measurement
- Discussion

Introduction

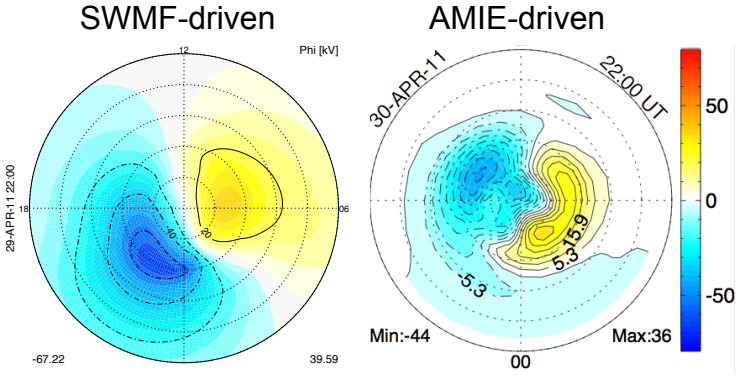
- GITM – Global Ionosphere-Thermosphere Model [Ridley et al., 2006, JASTP]
  - physics-based 3D model of the global ionosphere and thermosphere
  - altitude-based grid and does not assume hydrostatic equilibrium (nontraditional)
  - adjustable grid resolution
  - allow different models of high-latitude electric field, particle precipitation, solar EUV …


[Ridley et al., 2006, JASTP]

Simulation set-up

- Two events:
  - April 29 – May 1, 2011
  - May 8 – May 10, 2012
- Three types of GITM simulations:
  - **Weimer-driven** (empirical)
  - **AMIE-driven** (data assimilative)
  - **SWMF-driven** (Global MHD model + potential solver)

Example input convection patterns



The three drivers provide GITM with different convection patterns (major, affect Joule heating), and the last two also provide different electron precipitation patterns (affect Joule heating through conductivity, affect auroral heating) in high-latitude regions. The Weimer-driven simulation obtains precipitation patterns from NOAA's hemisphere power.

Common inputs: solar EUV flux, hemisphere power (builds background precipitation patterns in AMIE- and SWMF-driven simulations)

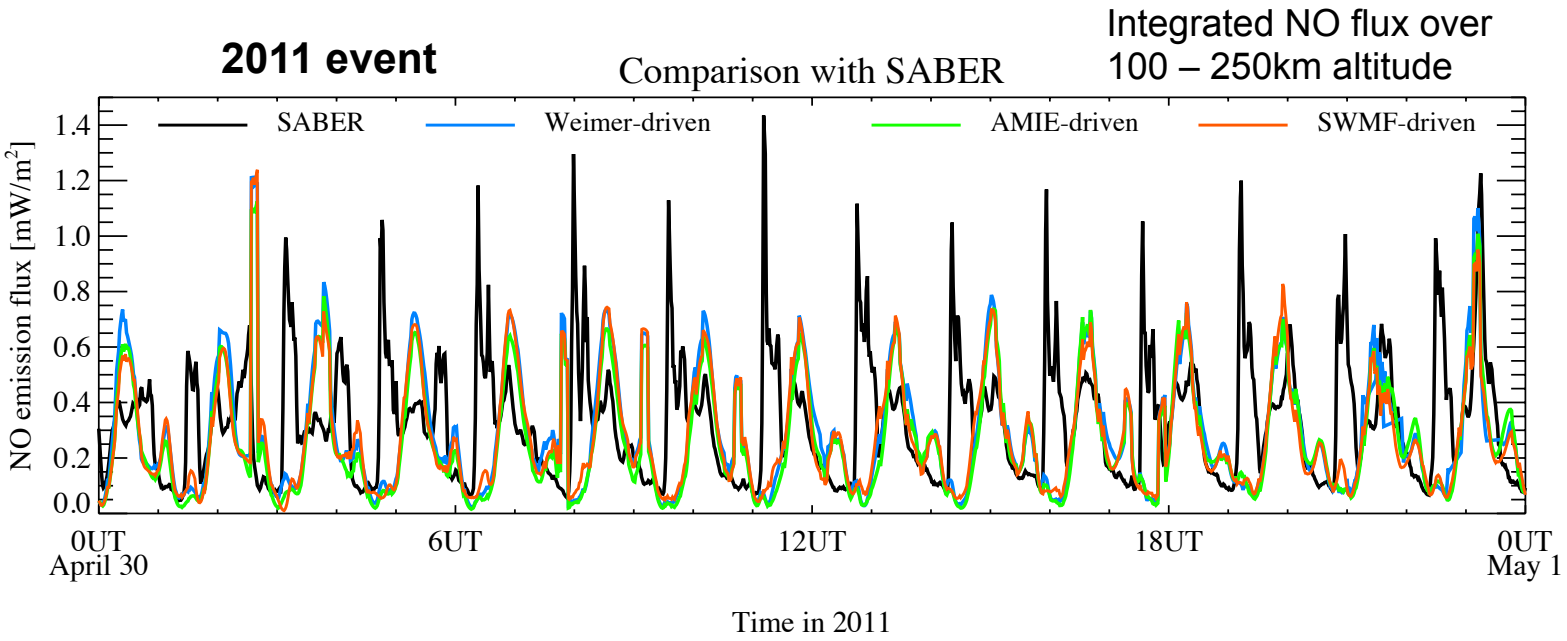
Nitric Oxide (NO) Cooling

- NO radiative cooling – releases most Joule heating energy
- Calculation of NO cooling in GITM

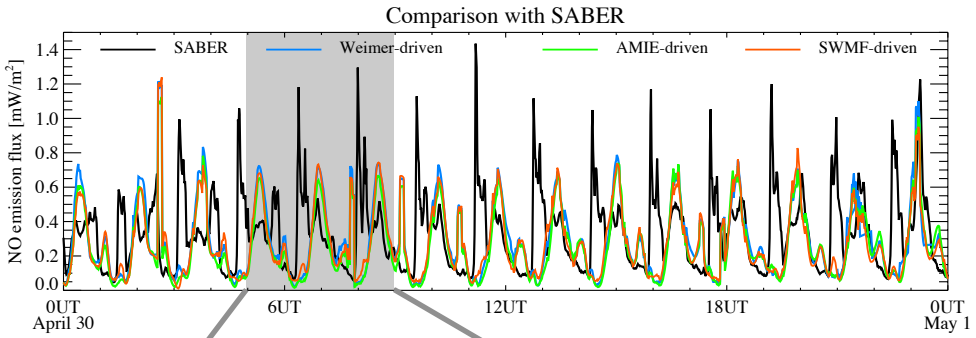
$$L_{NO} = 4.99 \times 10^{-19} \frac{kn(O)}{kn(O) + 13.3} \cdot n(NO) \cdot e^{-\frac{2718}{T}}$$

in J/m^3/s

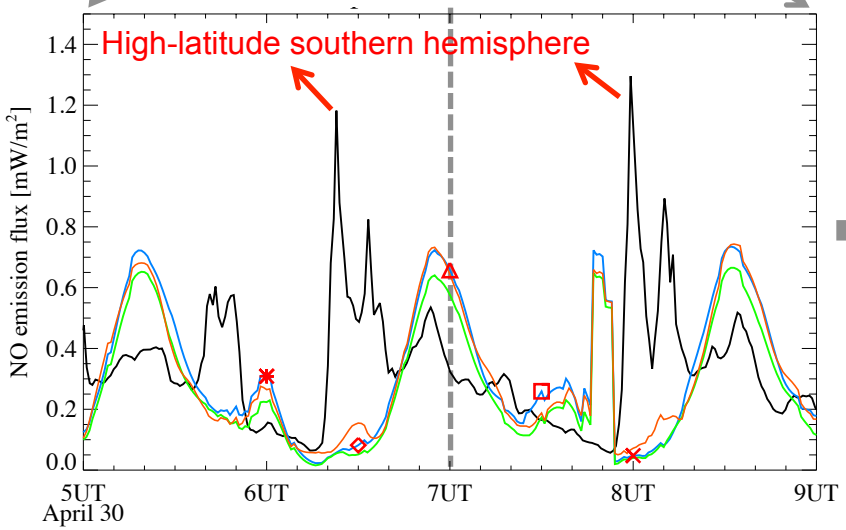
Vibrational relaxation of NO:
$NO_{v=1} + O \rightarrow NO_{v=0} + O$ reaction rate k

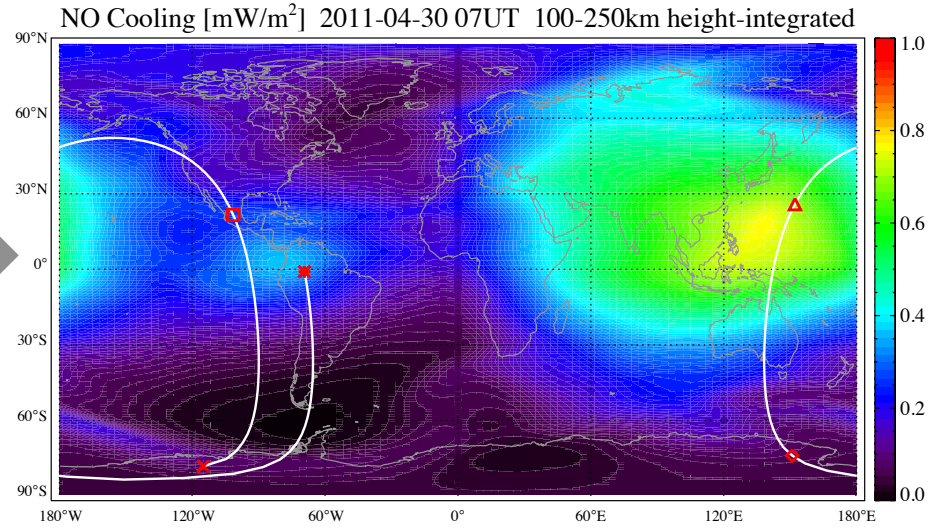


NO Cooling – 2011 event



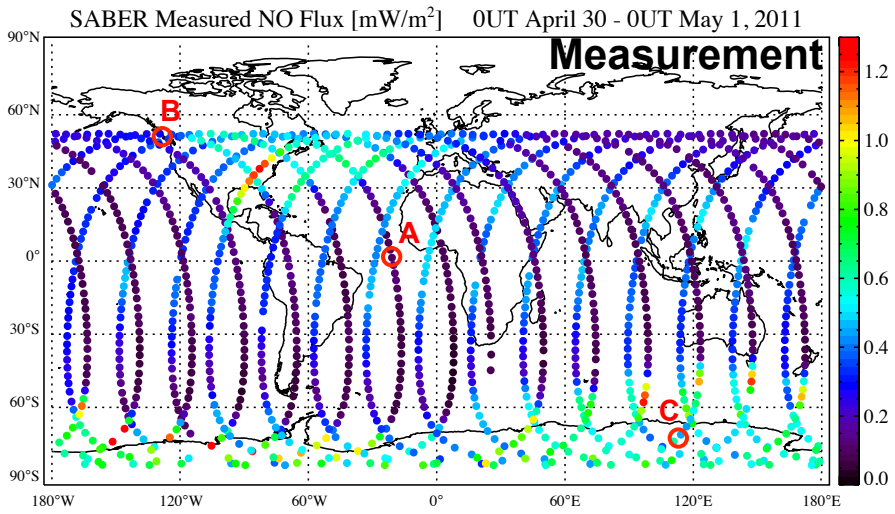
a single orbital period during the main phase of the storm

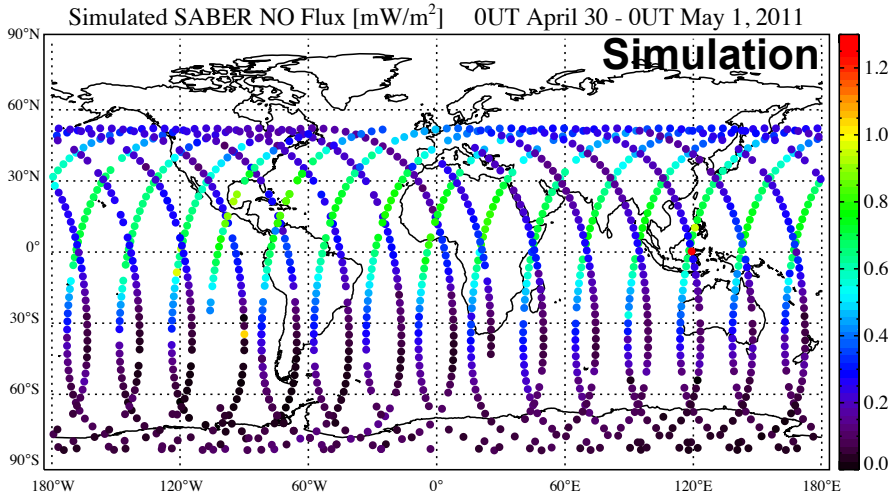




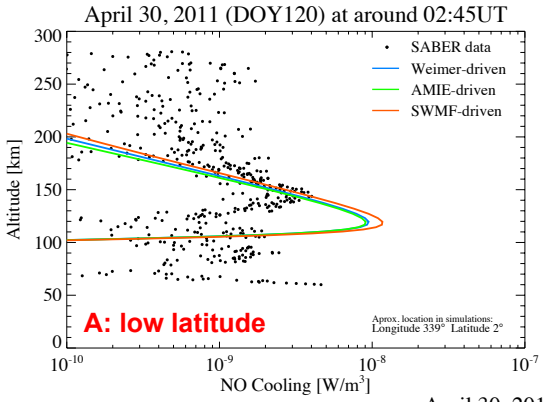
from the Weimer-driven simulation

NO Cooling – 2011 event

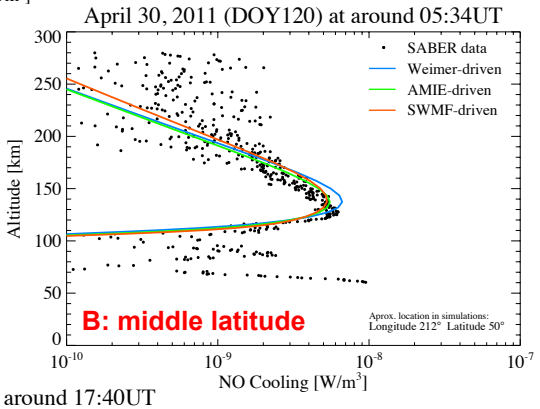


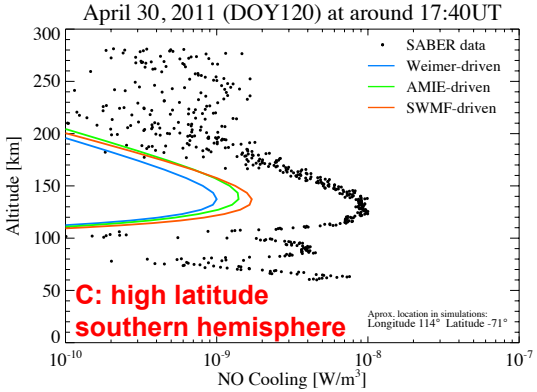


from the Weimer-driven simulation

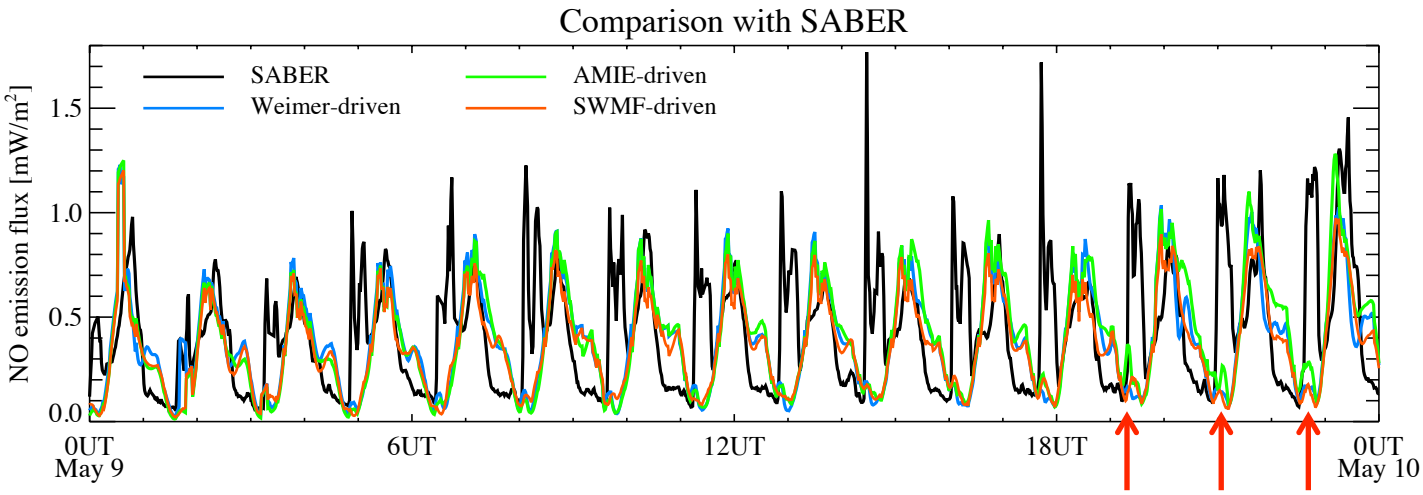


Vertical Profiles



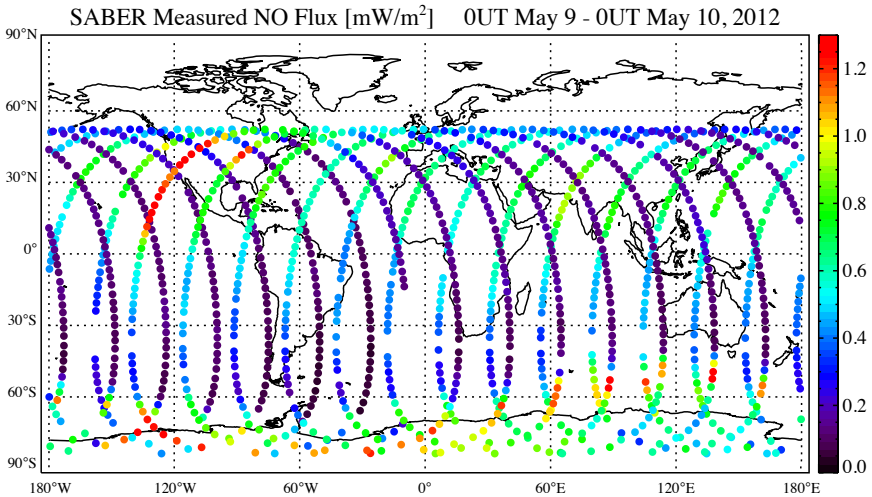


NO Cooling – 2012 event

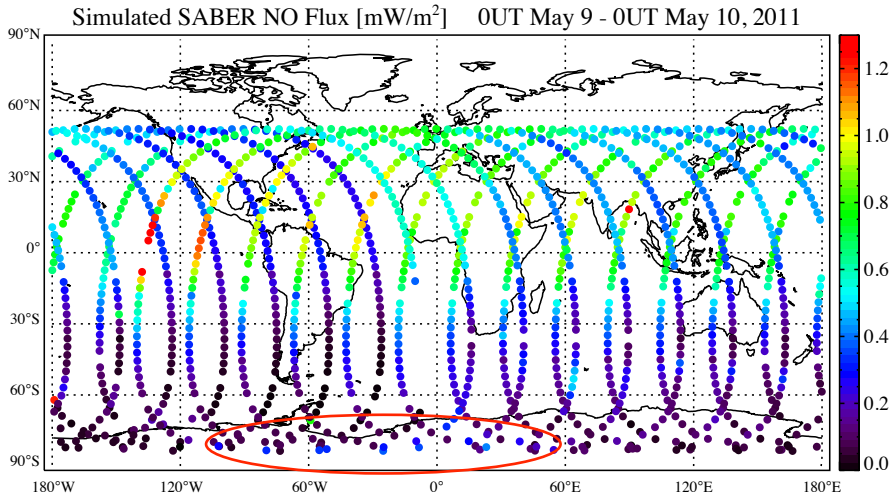


The AMIE-driven simulation shows slightly increased NO flux in the high-latitude region.

Measurement



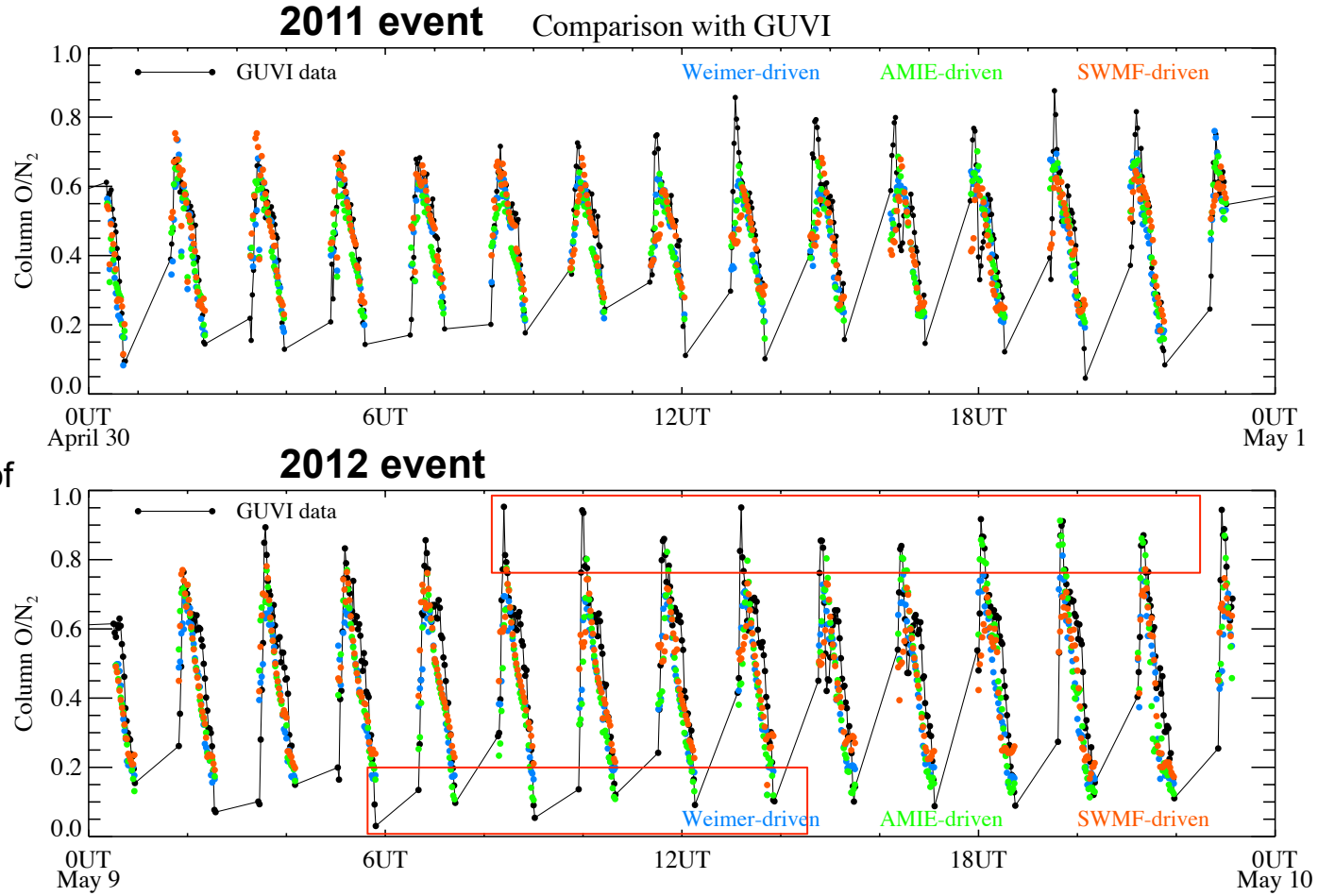
AMIE-driven Simulation



O/N_2

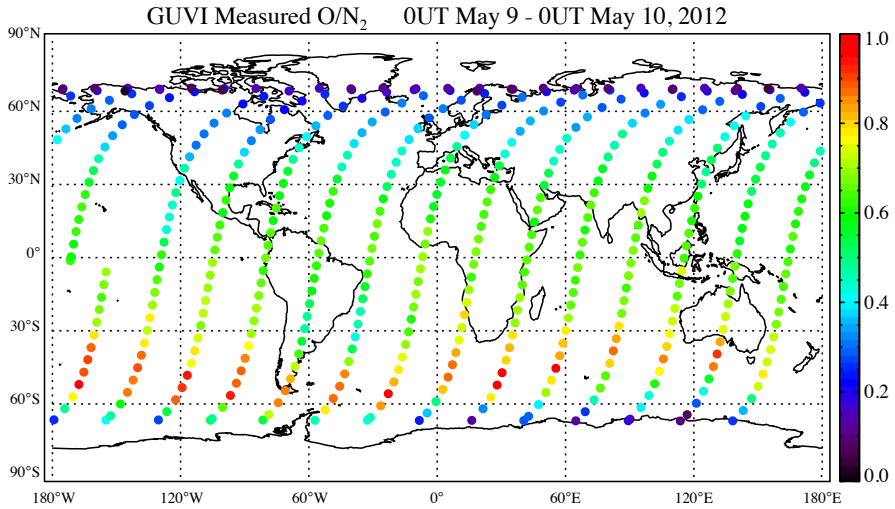
- O/N_2 indicates thermospheric composition changes due to upward winds during storms.

Column density ratio above the height where the column density of N_2 is $10^{17}cm^2$

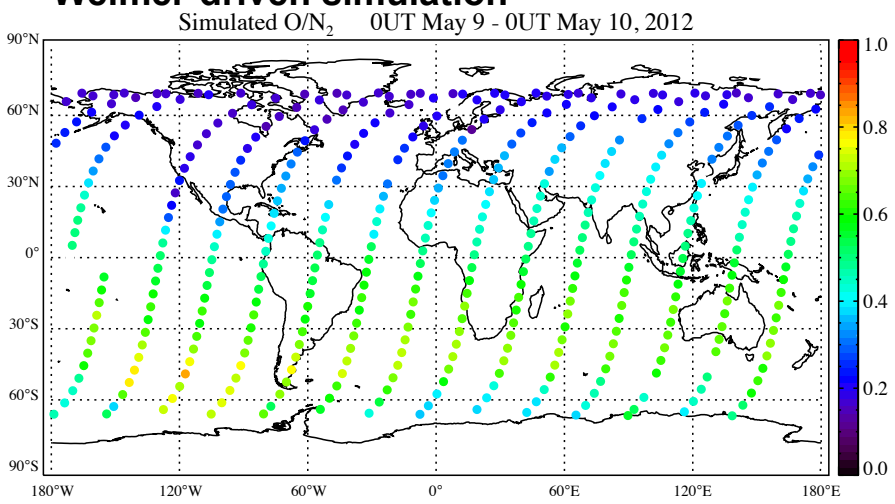


O/N_2 – 2012 event

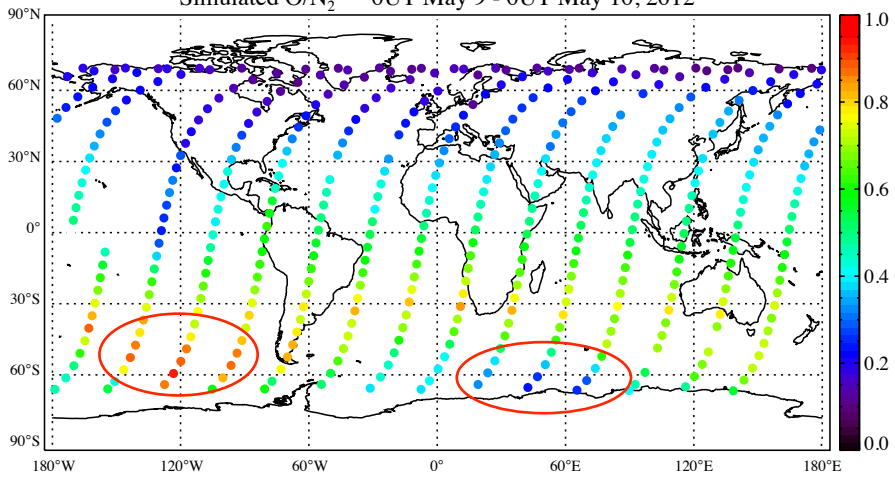
Measurement



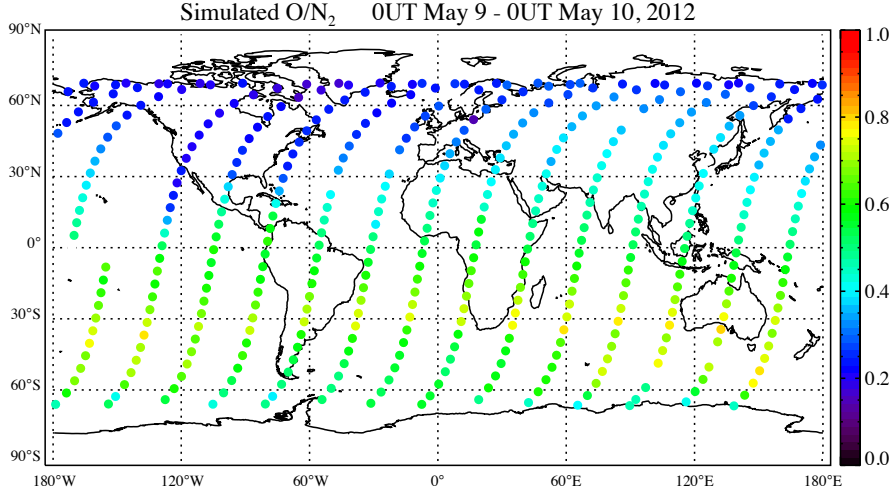
Weimer-driven simulation



AMIE-driven simulation



SWMF-driven simulation



Discussion

- Among the three types of GITM simulations, the AMIE-driven one reproduces the observed NO cooling flux and O/N_2 best, especially for the 2012 event.
- The AMIE-driven simulations used realistic high-latitude convection patterns derived from magnetometer data.
- The importance of high-latitude convection during HSS storms is a key factor to be considered for our forecasting effort. Poorly represented convection patterns could lead to large forecasting errors.
- More to look at: significant underestimation of NO cooling in high-latitude regions.

THANK YOU