1. Introduction

Plasmasphere:
Cold, dense region of plasma which extends from Earth’s upper atmosphere to the plasmapause [Carpenter, 1966; Nishida, 1966; Lemaire et al., 1998; Darrouzet et al., 2009].

Plasmaspheric dynamics:
- Quiet times:
  - ions and electrons in plasmasphere exist in dynamic equilibrium with upper atmosphere
- Erosion
  - Geomagnetic storms cause increased magnetospheric convection
  - Contracts to lower L shells
  - Plume formation in afternoon region [Grebowsky, 1970; Ober et al., 1997; Goldstein et al., 2004; Darrouzet et al., 2008].
- Refilling
  - low energy ionospheric plasma is drawn up from lower altitudes along magnetic field lines
  - plasma density increases
  - plasmapause moves outward

Plasmaspheric models:
- Statistical average and static models:
  - Equatorial empirical models:
    - Ne = f (L,MLT) in plasmasphere and trough regions [Sheeley et al., 2001]
- 3D empirical models (field-aligned profiles)
  - Polar orbiting satellite observation
  - Not enough to represent refilling and those processes

Dynamic density models with spatio-temporal continuous output:
- Data-sparse sparse satellite observations (data intensive)
- DEN2D (equatorial)
- DEN3d (along field lines)

2. Methods

Development of a three-dimensional dynamic electron density model (DEN3D) using a feedforward neural network:

Input data:
- Satellite data from CRRES, ISEE, IMAGE, and POLAR:
  - Electron density, L-dipole value, Magnetic Local Time (MLT), Magnetic Latitude (MLAT)
  - 1977 to 2005
- Solar wind parameters:
  - From NASA’s OMNI database
  - Flow speed, SYM-H index, AL index, and AE index
  - 1961 to 2005

Neural network model:
- Two layer fully-connected model
- Neurons in each layer: [30,10]
- Early stopping and Dropouts applied to eliminate overfitting
- Adjusts weights to minimize the mean squared errors (MSE)

3. Performance and Data-Model Comparison

When Applied to geomagnetic storm in March 20 to June 10 of 2001:

4. Application

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