Comparison of TIE-GCM and C/NOFS ion velocity using PysatMagVect

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Assimilative Analysis of Low- and Mid-latitude Ionospheric Electrodynamics

University of Colorado Boulder

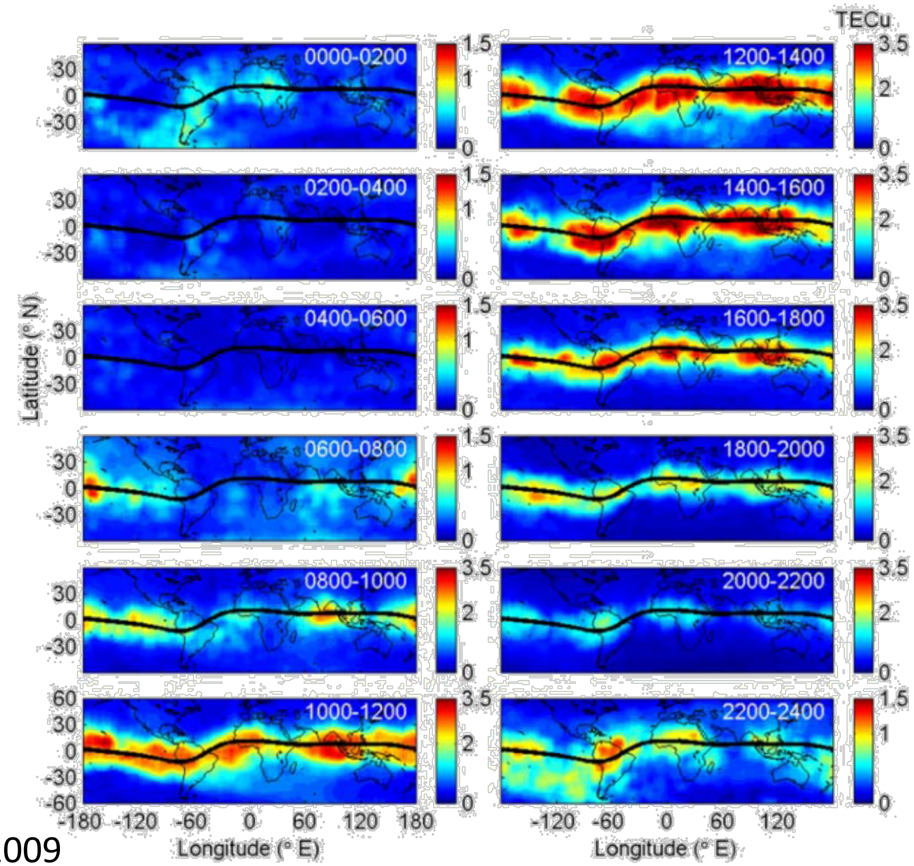
High Altitude Observatory
NCAR UCAR

CCAR

Motivation

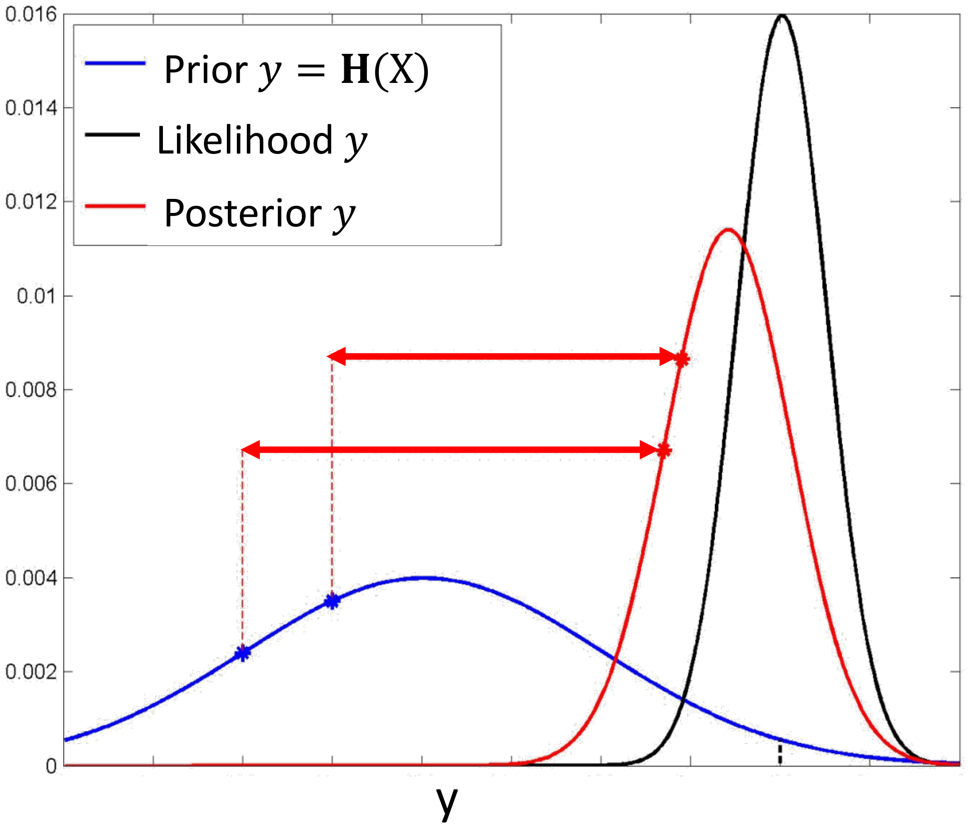
To improve the understanding of the variability of the dayside, low-latitude, and global-scale ionospheric electrodynamics.

- COSMIC and C/NOFS data are going to be assimilated into the data-driven, first-principle, and numerical model to provide a comprehensive vision of variability of ionospheric electrodynamics.



Lin et al., 2009

Data assimilation of C/NOFS ion velocity



Model:

TIE-GCM driven by

1. Assimilative Mapping of Geospace Observation
2. F10.7 data
3. Modern-Era Retrospective Analysis for Research and Application (MERRA)-driven TIME-GCM.

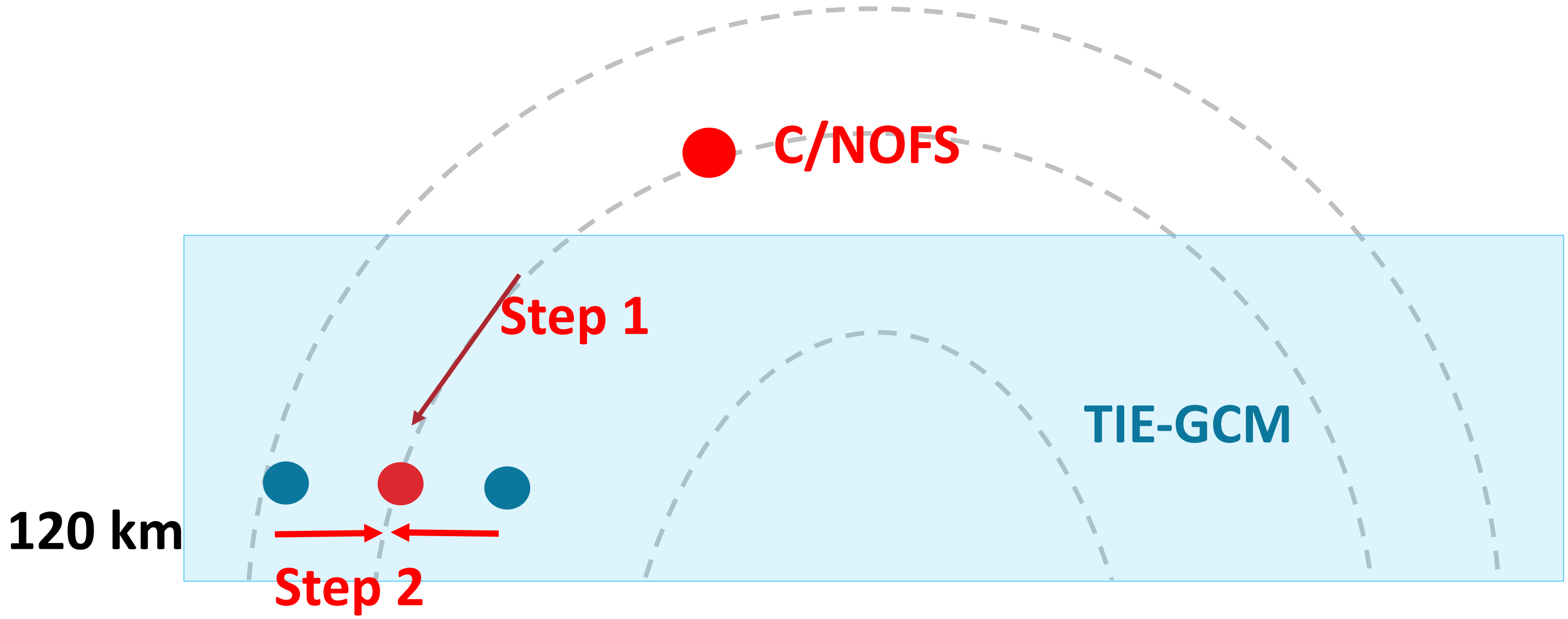
The upper boundary is about 400 to 700 km depending on solar activity

Observation:

C/NOFS CINDE IVM ion drift velocity.

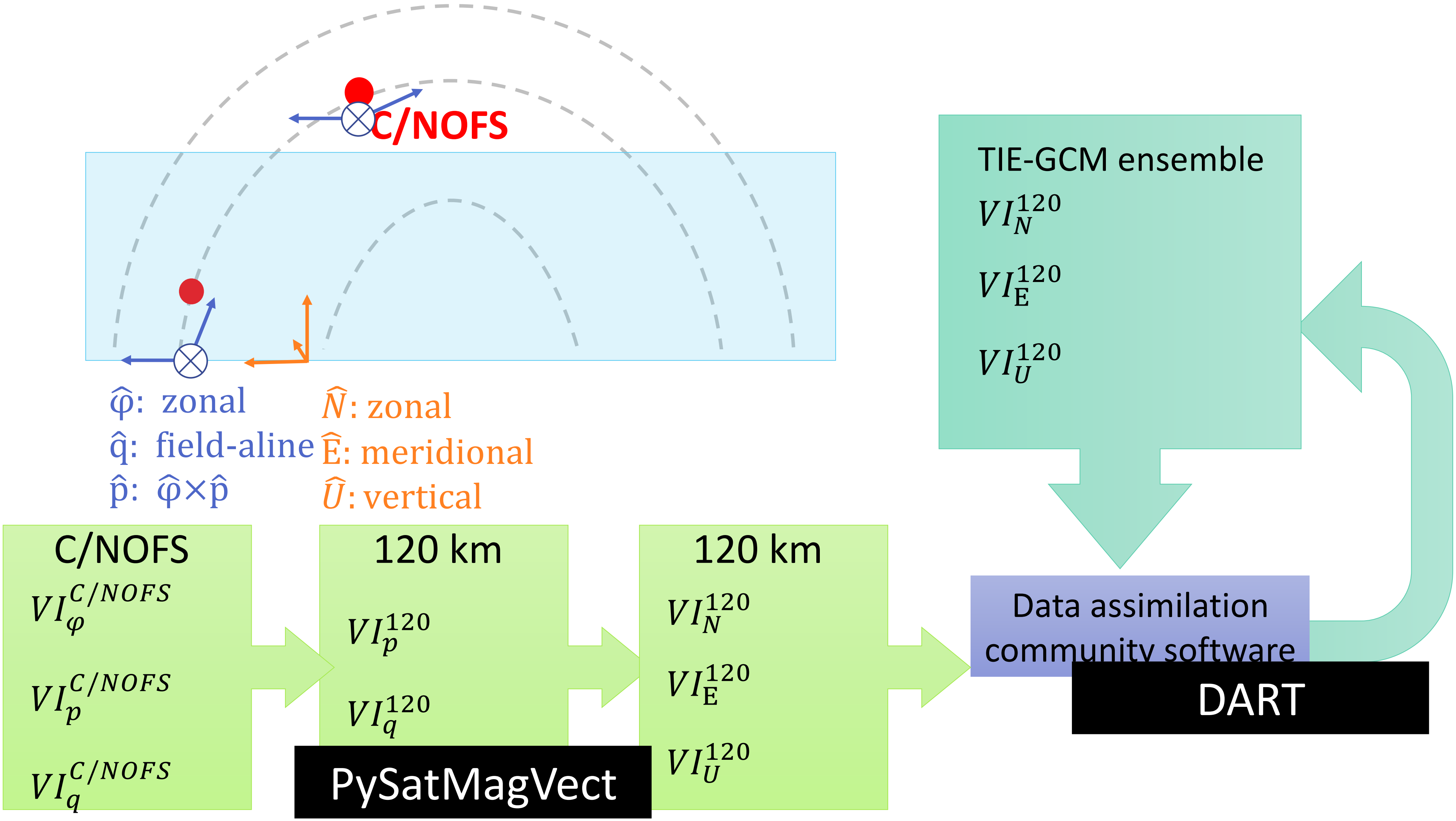
The orbit is at about 405 to 853 km altitude

How to compare observations with the model



Step 1. Mapping the data from C/NOFS location to 120 km altitude.

Step 2. Interpolating TIE-GCM ion velocity horizontally from model grid to the footpoint point.


C/NOFS
$\hat{\varphi}$: zonal
$\hat{q}$: field-aline
$\hat{p}$: $\hat{\varphi}\times\hat{p}$
$\hat{N}$: zonal
$\hat{E}$: meridional
$\hat{U}$: vertical
TIE-GCM ensemble
VI_N^{120}
VI_E^{120}
VI_U^{120}
C/NOFS
$VI_\varphi^{C/NOFS}$
$VI_p^{C/NOFS}$
$VI_q^{C/NOFS}$
120 km
VI_p^{120}
VI_q^{120}
PySatMagVect
120 km
VI_N^{120}
VI_E^{120}
VI_U^{120}
Data assimilation community software
DART

Open Source Community Software

Python Satellite Data Analysis Tookit (Pysat MagVect) –

Pysat is a python package that aims to support analyzing scientific measurements of all instruments in space science. PysatMagVect can help us to calculate the geomagnetic field direction and understanding the movement of plasma.

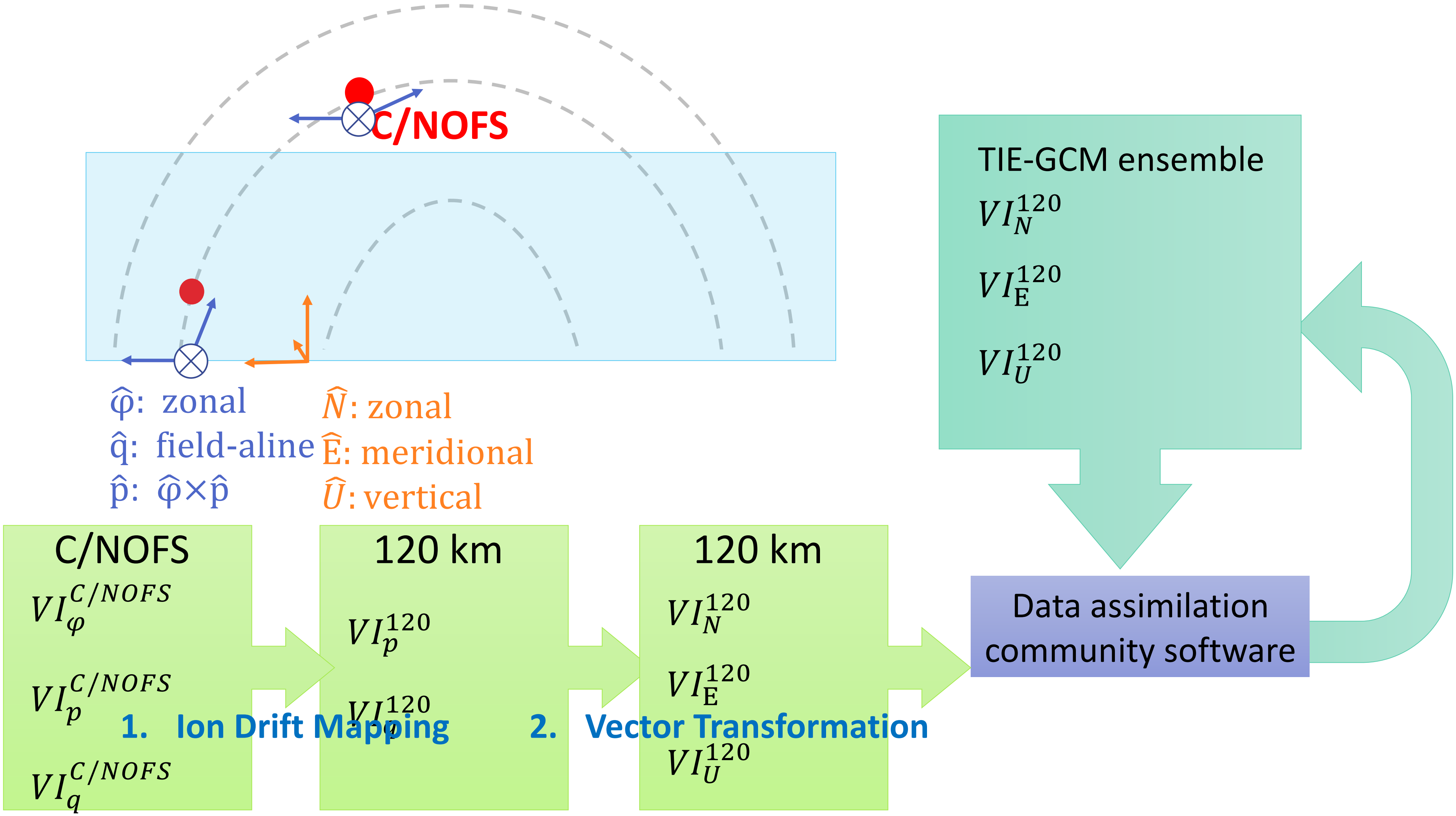
1. Ion Drift Mapping
2. Vector Transformation

pymv.scalars_for_mapping_ion_drifts(glats, glons, alts, dates, step_size, max_steps, efield_scaling_only)

Data Assimilation Research Testbed (DART) –

Fortran software tools for ensemble data assimilation developed and maintained by Data Assimilation Research Section at National Center for Atmospheric Research.

- Ensemble Adjustment Kalman Filter module


C/NOFS
φ̂: zonal
q̂: field-aline
p̂: φ̂×p̂
N̂: zonal
Ê: meridional
Û: vertical
TIE-GCM ensemble
VI_N^{120}
VI_E^{120}
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C/NOFS
$VI_\varphi^{C/NOFS}$
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120 km
VI_p^{120}
VI_φ^{120}
120 km
VI_N^{120}
VI_E^{120}
VI_U^{120}
Data assimilation community software
1. Ion Drift Mapping
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PySatMagVect

PySat can help us:

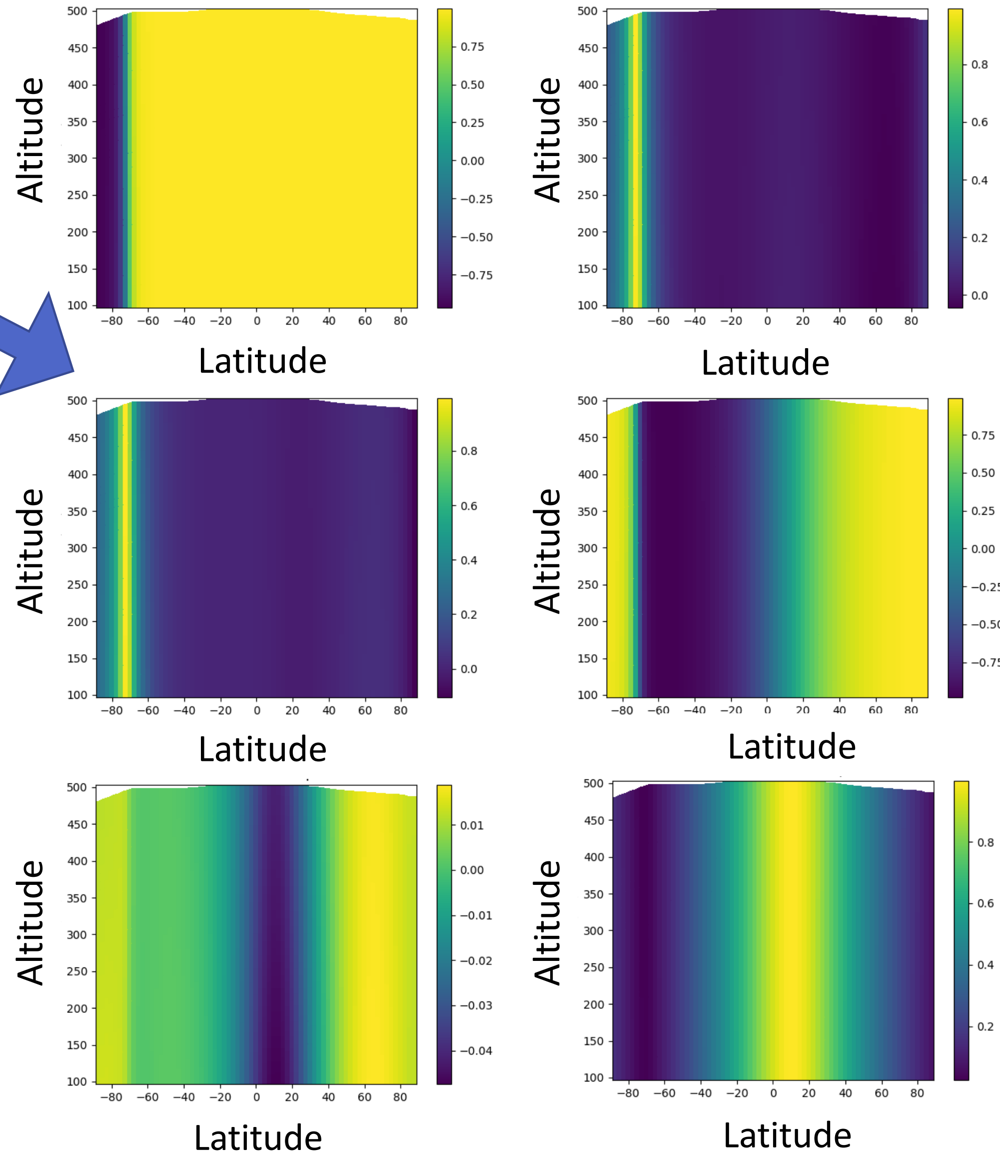
1. Compute scalars of mapping along APEX coordinate with the assumption of equal potential along the geomagnetic field line.
2. Compute the direction of geomagnetic field at given location.
3. Combination of 1 and 2

$$\begin{bmatrix} VI_{\varphi}^{120} \\ VI_{q}^{120} \end{bmatrix} = \begin{bmatrix} a^{1} & 0 \\ 0 & a^{2} \end{bmatrix} \begin{bmatrix} VI_{\varphi}^{C/NOFS} \\ VI_{q}^{C/NOFS} \end{bmatrix} \text{ and } \begin{bmatrix} VI_{E}^{120} \\ VI_{N}^{120} \\ VI_{U}^{120} \end{bmatrix} = \begin{bmatrix} b^{11} & b^{12} \\ b^{21} & b^{22} \\ b^{31} & b^{32} \end{bmatrix} \begin{bmatrix} VI_{\varphi}^{120} \\ VI_{q}^{120} \end{bmatrix}$$

$$\begin{bmatrix} VI_{E}^{120} \\ VI_{N}^{120} \\ VI_{U}^{120} \end{bmatrix} = \begin{bmatrix} b^{11} & b^{12} \\ b^{21} & b^{22} \\ b^{31} & b^{32} \end{bmatrix} \begin{bmatrix} a^{1} & 0 \\ 0 & a^{2} \end{bmatrix} \begin{bmatrix} VI_{\varphi}^{C/NOFS} \\ VI_{q}^{C/NOFS} \end{bmatrix} = \begin{bmatrix} c^{11} & c^{12} \\ c^{21} & c^{22} \\ c^{31} & c^{32} \end{bmatrix} \begin{bmatrix} VI_{\varphi}^{C/NOFS} \\ VI_{q}^{C/NOFS} \end{bmatrix}$$

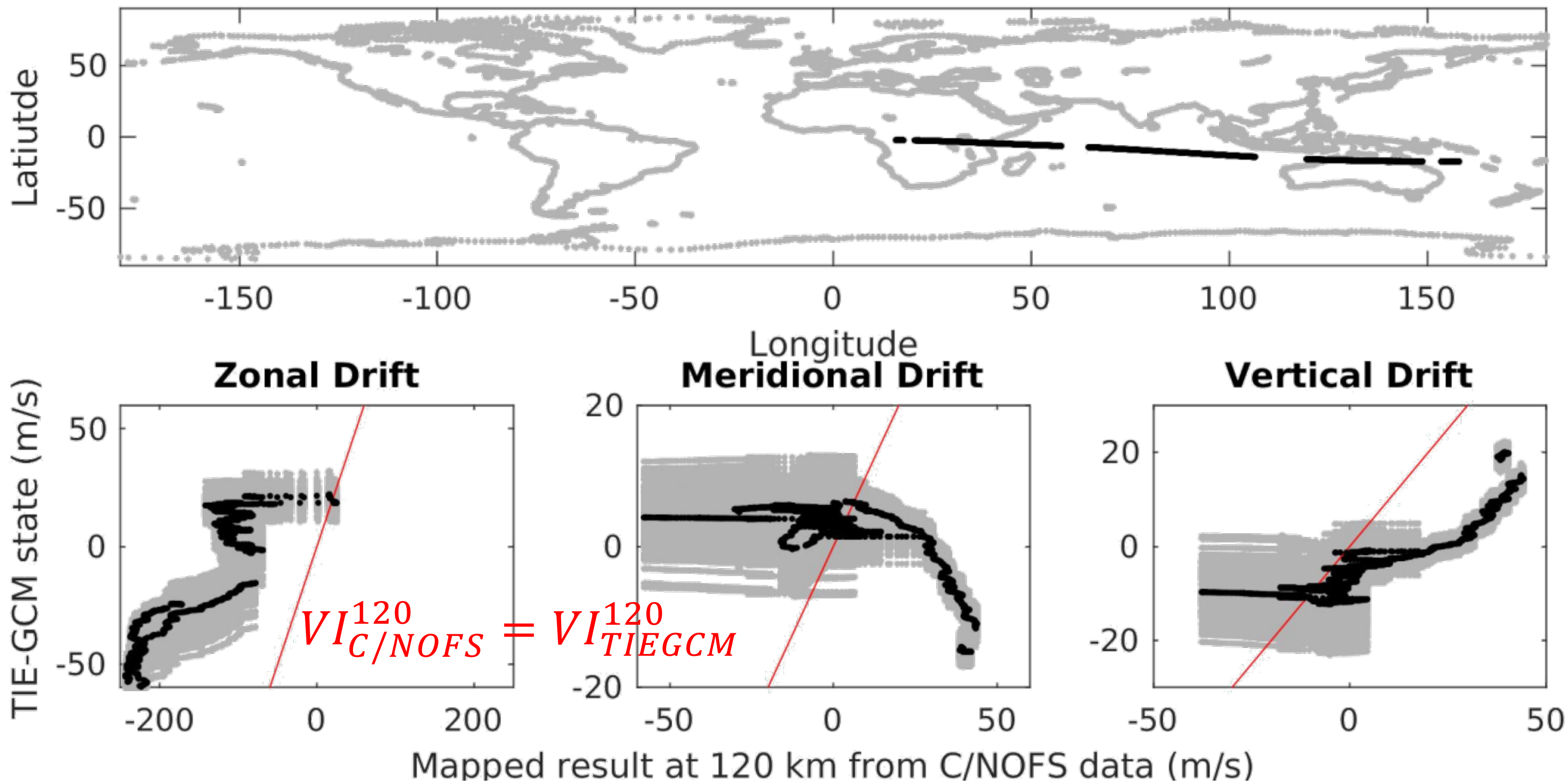
$$\begin{bmatrix} VI_E^{120} \\ VI_N^{120} \\ VI_U^{120} \end{bmatrix} = \begin{bmatrix} c^{11} & c^{12} \\ c^{21} & c^{22} \\ c^{31} & c^{32} \end{bmatrix} \begin{bmatrix} VI_\varphi^{C/NOFS} \\ VI_q^{C/NOFS} \end{bmatrix}$$

$$\begin{matrix} VI_E^{120} \\ VI_N^{120} \\ VI_U^{120} \end{matrix} =$$



$$\begin{matrix} VI_\varphi^{C/NOFS} \\ VI_q^{C/NOFS} \end{matrix}$$

Comparison between 95 TIE-GCM ensemble and C/NOFS ion drift velocity (March 12, 2009)



Summary

- With the help of PySatMegVect, we are able to
    1. map C/NOFS ion velocity to the TIE-GCM framework
    2. transform data from geomagnetic coordinate to geographic coordinate.

- In comparsion to the C/NOFS ion velocity, the plasma drift simulated by the TIE-GCM is underestimated, especially zonal component. A more comprehensive comparison between C/NOFS ion velocity and the TIE-GCM need to be carried out to assess the model bias.

Relevant Poster: DATA03, Poster section, Tuesday