INTERCOMPARISION OF SSUSI (-BASED MODEL) AND AISSTORM

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DLR

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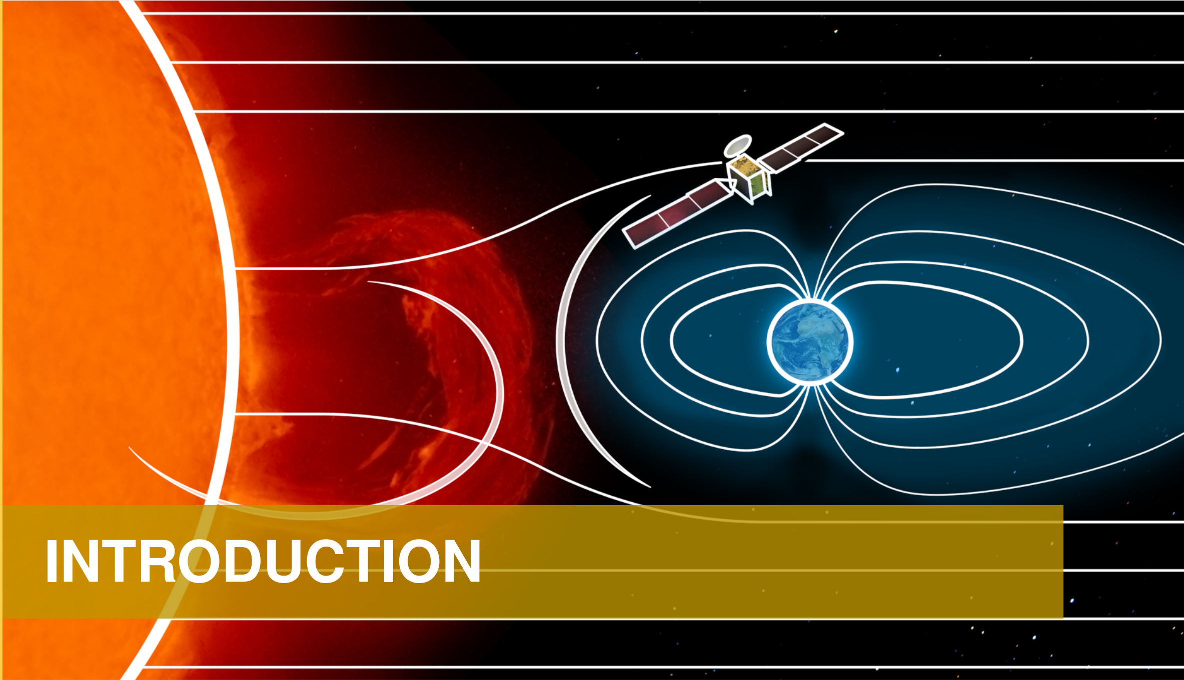
5. Summary



INTRODUCTION

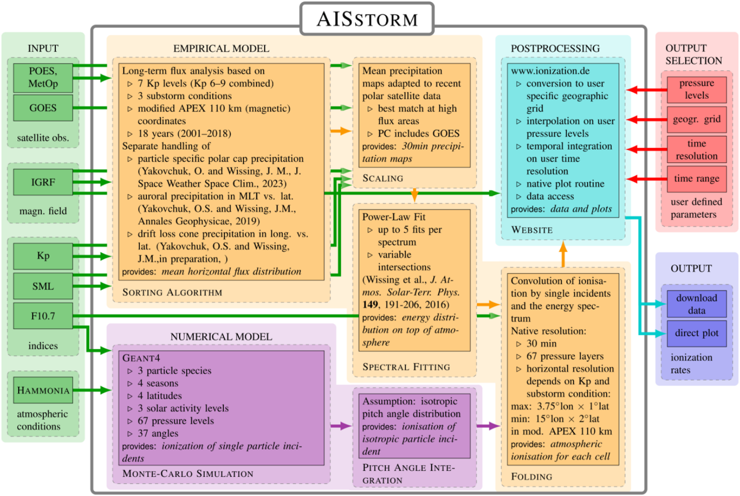
Motivation

- Ionization rates are typically based on space-born particle measurements
    - always mixes spatial and temporal variations
- Auroral particles in AISstorm are measured by TED on POES/Metop:
    - rarely used detector, may have inherent unknown issues
- Verification of ionization rates itself problematic:
    - always affords model chain: ionization model + climate model (+ retrieval method for measurements)
    - EISCAT available for single locations only, no global coverage

- SUSSI
    - Special Sensor Ultraviolet Spectrographic Imager
    - measures 2D UV emissions from aurora
    - only valid for a limited altitude range
    - does not mix spatial and temporal variations

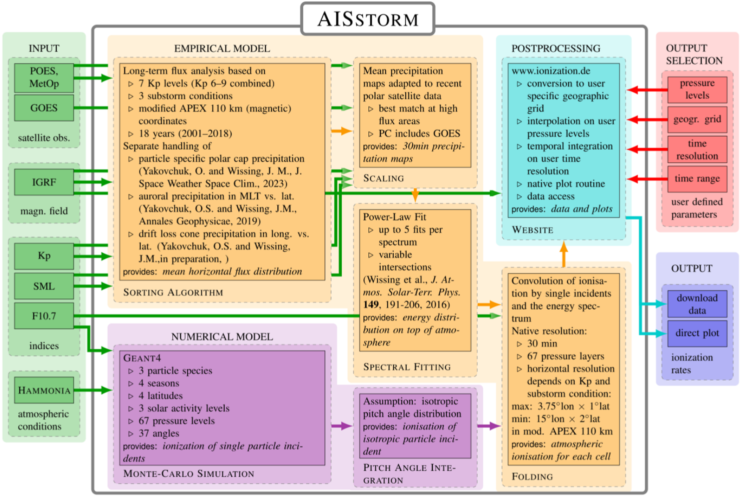
  → allows construction of ionization models which be compared to "conventional" ionization models

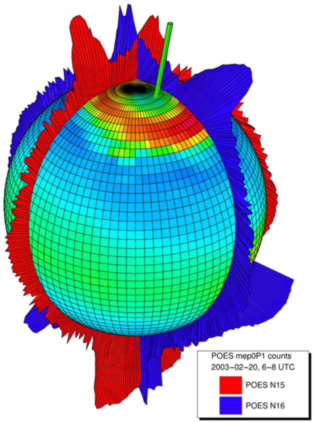
Introduction: AISstorm



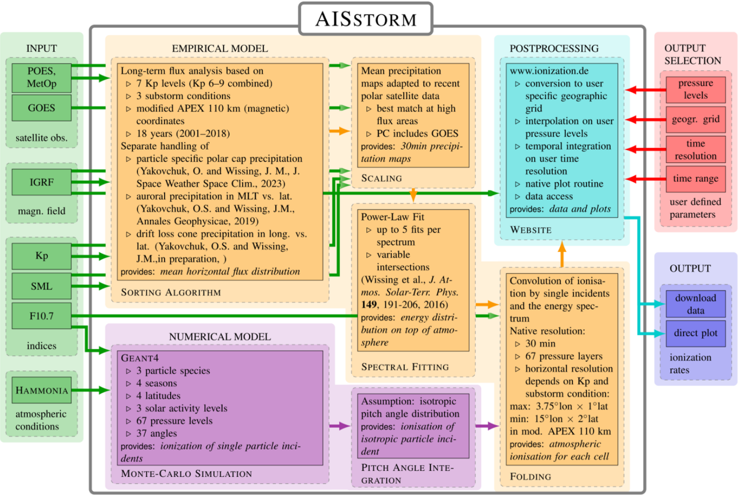
Has been introduced in a talk yesterday.

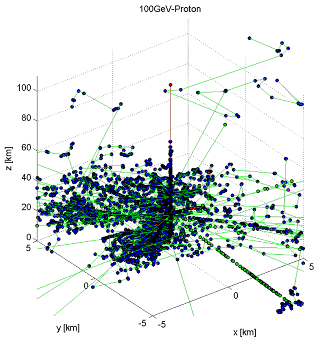
Introduction: AISstorm



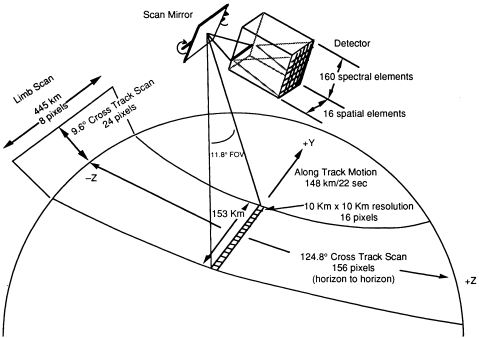


Introduction: AISstorm



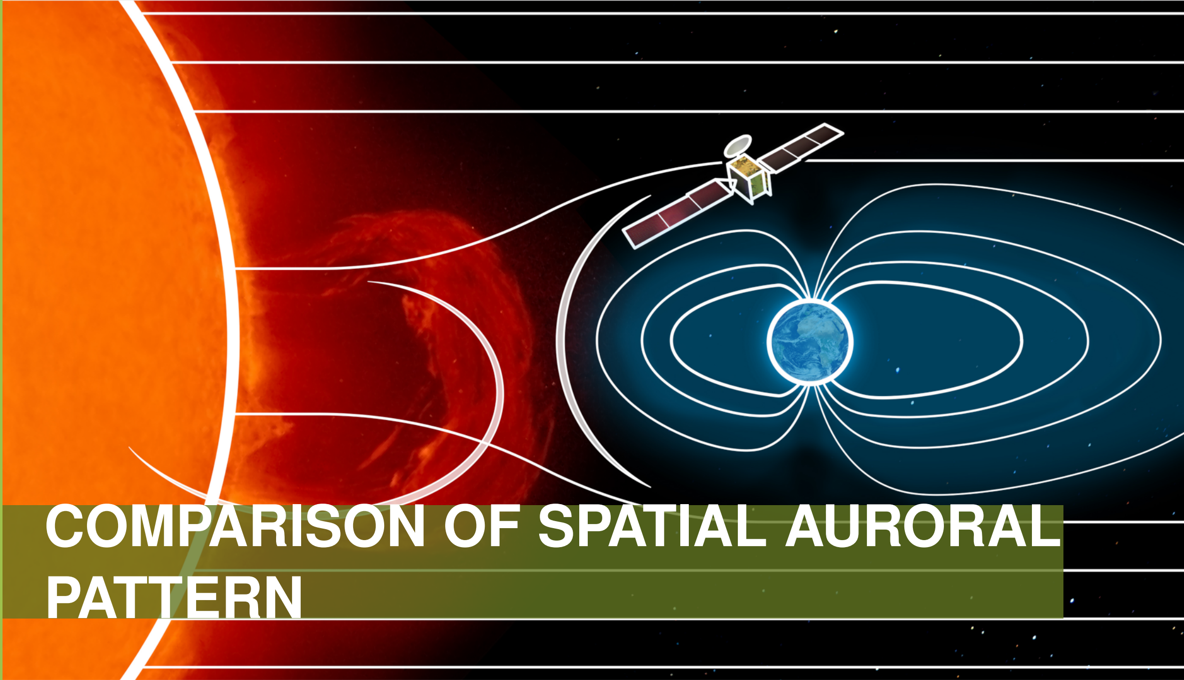


Introduction: SSUSI model

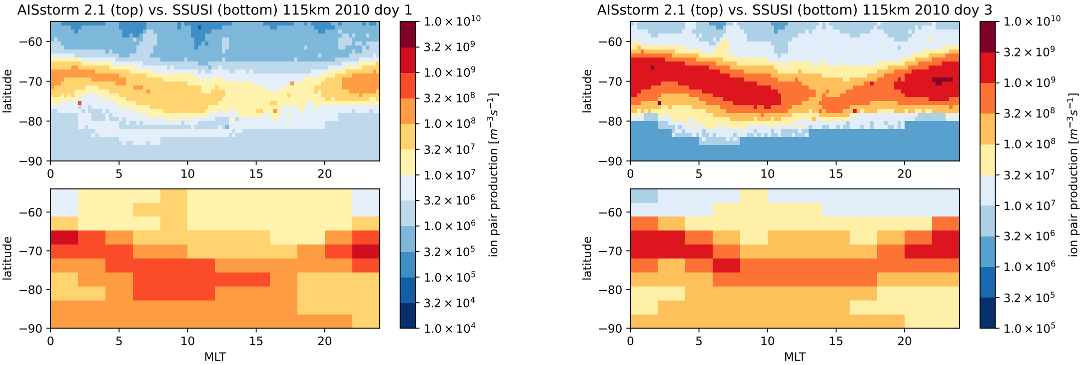


- SSUSI
  - Auroral energy input based on *Special Sensor Ultraviolet Spectrographic Imager*
  - Defense Meteorological Satellite Program (DMSP) satellites (850 km)
  - nadir auroral images, 5 UV channels, 10×10 km ground pixels
  - auroral electron energy (2-20 keV) and energy flux [mW m-2]
- SSUSI model (Bender et al., 2021)
  - $3.6°$ geomagnetic latitude $\times$ 2-h magnetic local time (MLT) grid, 5 km altitude grid
  - transformed into ionization rates using (Fang et al., 2010) $\rightarrow$ IR profiles from 90 to 150 km
  - model: log q $\sim$ Kp + PC + Ap + log F10.7 + const.

COMPARISON OF SPATIAL AURORAL PATTERN

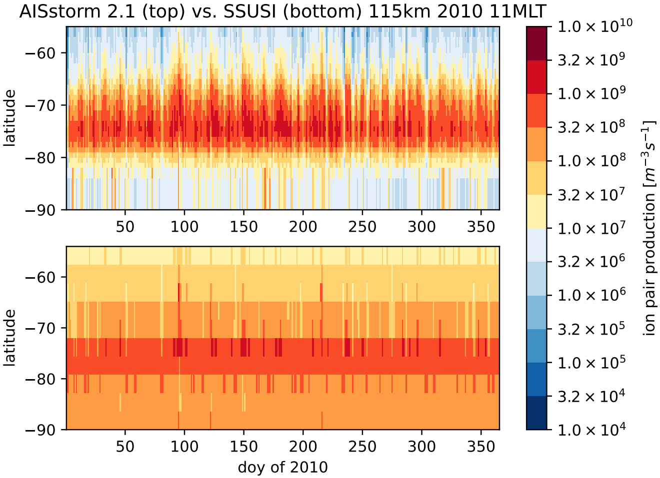


Comparison of spatial auroral pattern



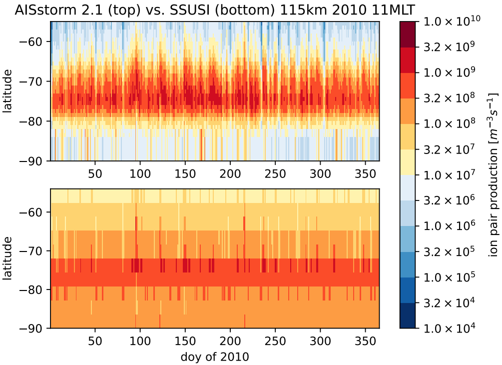
- altitude selection 115 km (auroral ionization rate maximum in AISstorm)
- latitudinal and MLT distribution very similar
- quantification: central aurora varies between perfect match and factor 10 difference
- SSUSI shows significantly more ionization rate in polar and subauroral latitudes

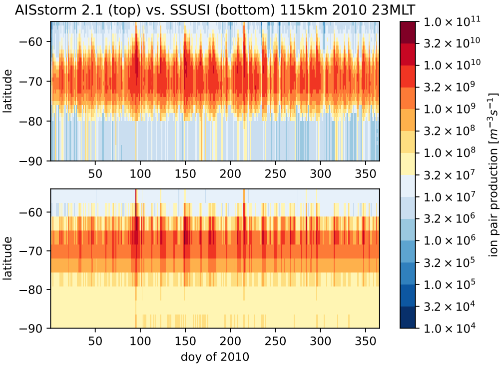
Comparison of spatial auroral pattern - long term



- dynamical range in AISstorm seems to be higher (vertical pattern needed)
- at high activity rather similar, growing differences for low activity
- latitudes of main aurora agree very well
- cap in AISstorm just partly filled

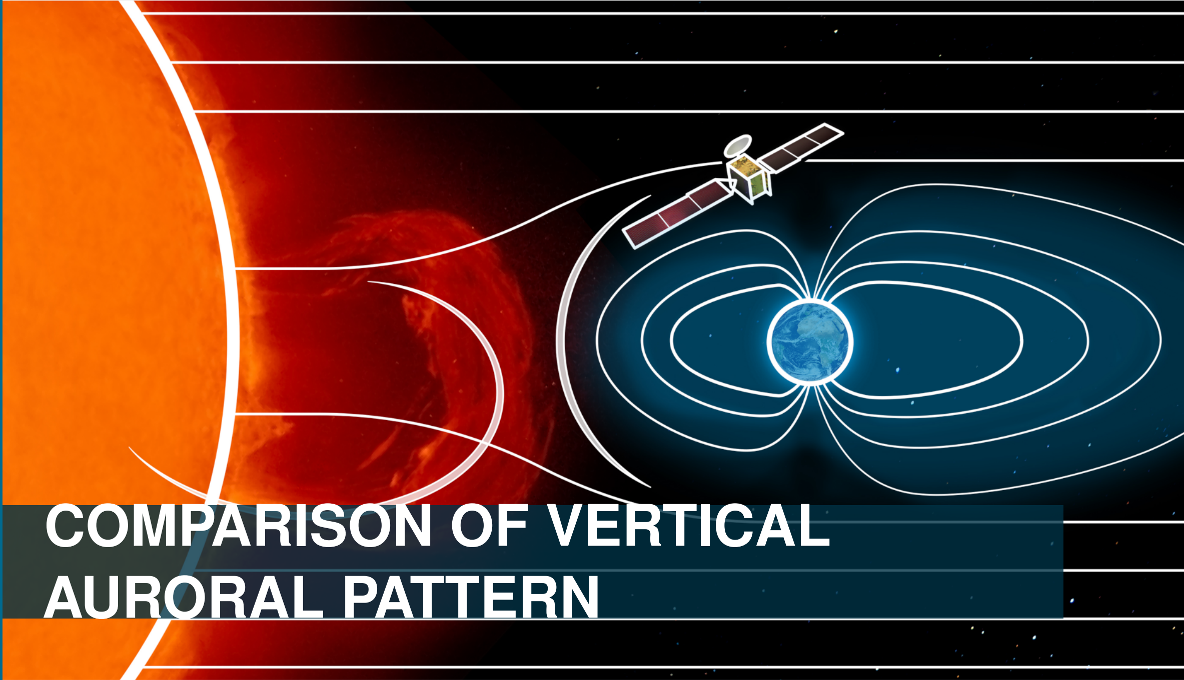
Comparison of spatial auroral pattern - long term



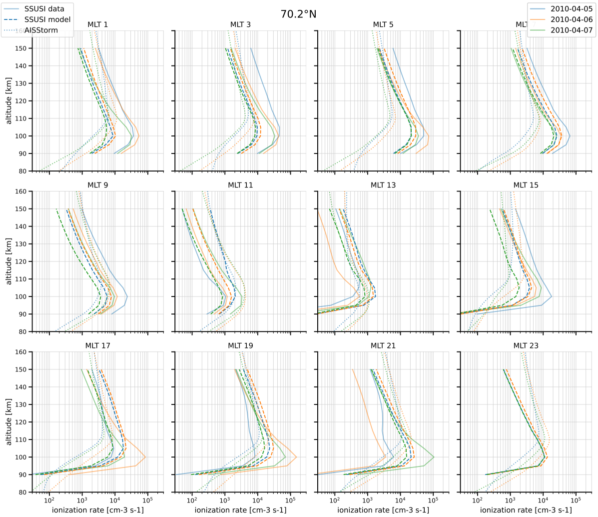


- similar picture for other MLTs

COMPARISON OF VERTICAL AURORAL PATTERN

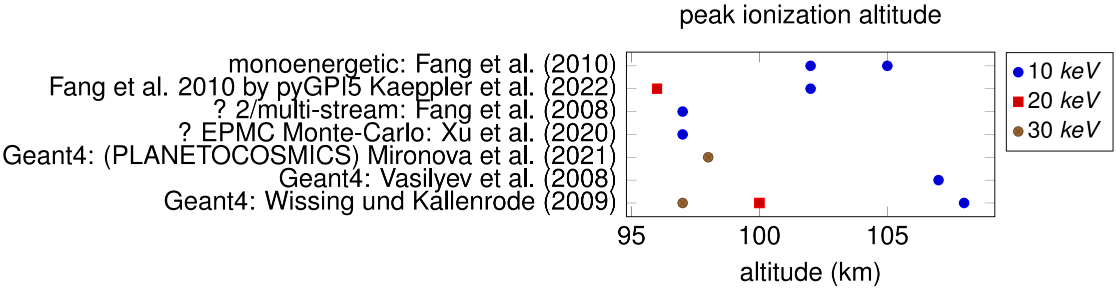


Comparison of vertical auroral pattern



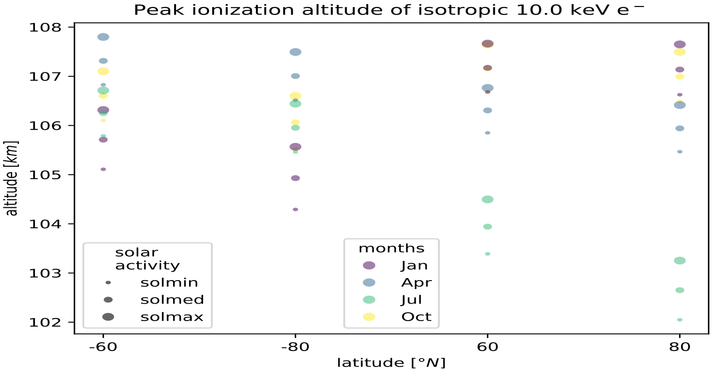
- SSUSI (data/model) ionization rate peaks are mostly at 100 km (between 15-19 MLT mostly at 105 km)
- AISstorm ionization rate peaks are mostly at 110 km (between 9-13 MLT at about 100 km, typically MLT minimum precipitation)
- steeper slope of AISstorm ionization rate above peak
- factor 5 between SSUSI data and SSUSI model

Other studies



- There seem to be a systematic difference between Fang et al. 2010 and Geant4 based models.
- But all models use different atmospheric parameters.

Peak ionization altitudes of 10 keV e^- using Geant

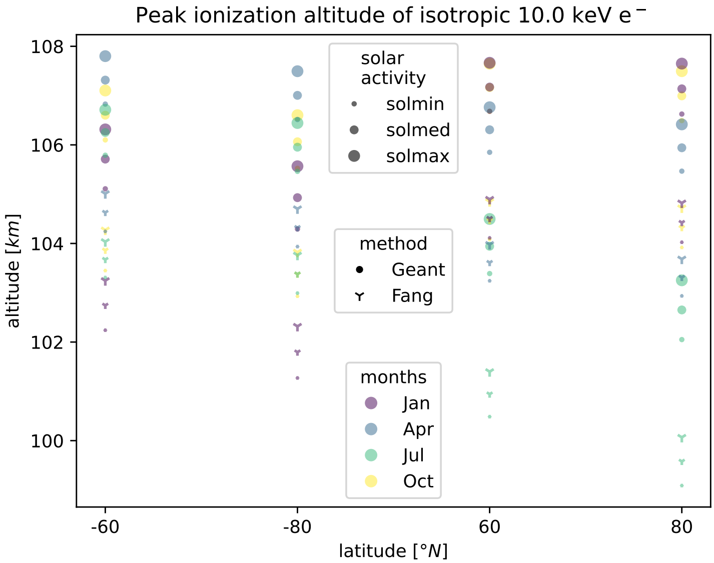


- atmospheric parameters from HAMMONIA long-term runs
- solar activity (F10.7 flux):
  - solmin: 68 sfu,
  - solmax: 235 sfu
  - solmed: mean
- 4 latitudes
- 4 seasons

→ altitude: 102-108 km (except for northern summer: 104-108 km)

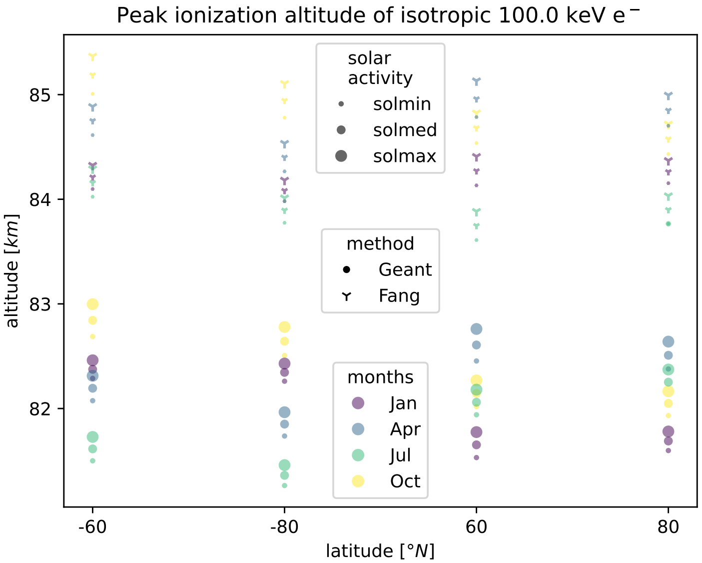
- note: altitude defined by half level height of bin, bin size ≈2.5-3.5km

Peak ionization altitudes of 10 keV e⁻ using Geant & Fang



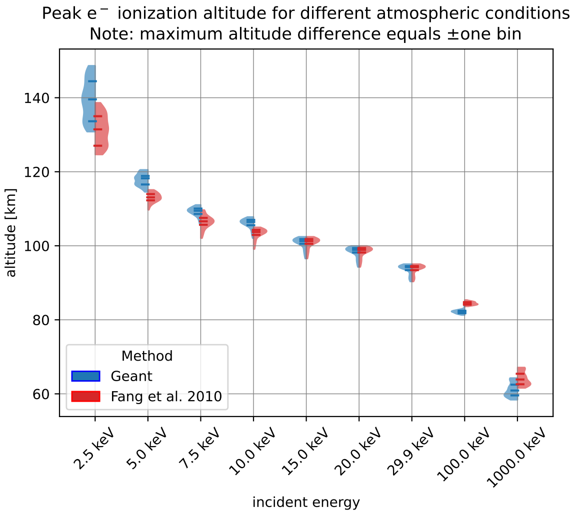
- same atmospheric parameters
- ⋎ Fang et al. 2010
- ionization peak clearly (one bin) below

Peak ionization altitudes of 100 keV e⁻ using Geant & Fang



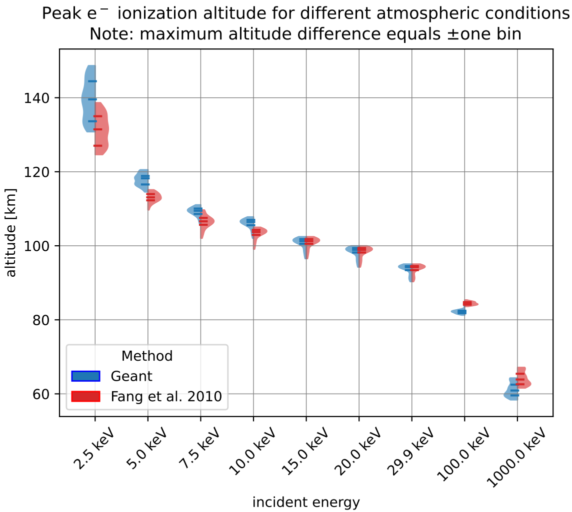
- same for 100 keV
- ⋎ Fang et al. 2010
- ionization peak clearly (one bin) above

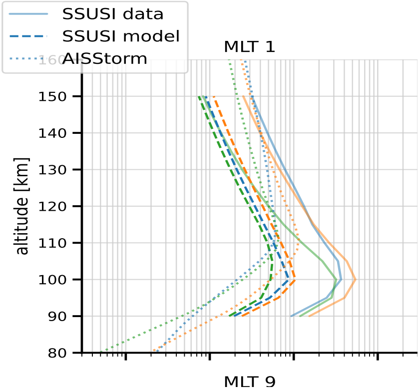
Geant vs. Fang for typical auroral energies



- Ionization rate peak for Fang is:
  - at lower altitudes for energies below 15 keV
  - at similar altitudes for energies 15-30keV
  - at higher altitude for energies above 30 keV
- note: Geant has different options, but Planetocosmics seems to be similar to our settings.

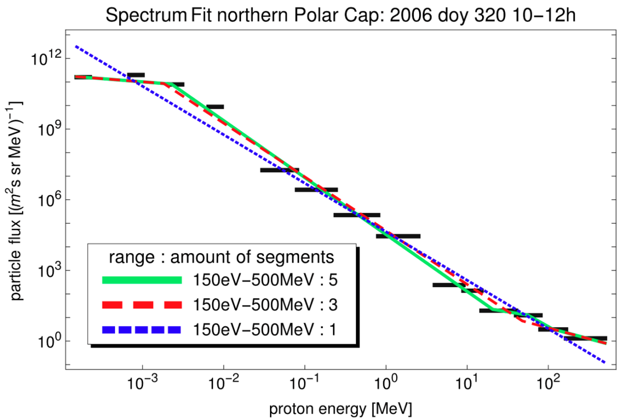
Geant vs. Fang for typical auroral energies

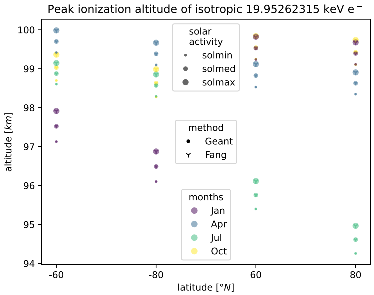




- explains steeper slope of AISstorm rates
- (just) partly explains different peak altitude of combined spectrum

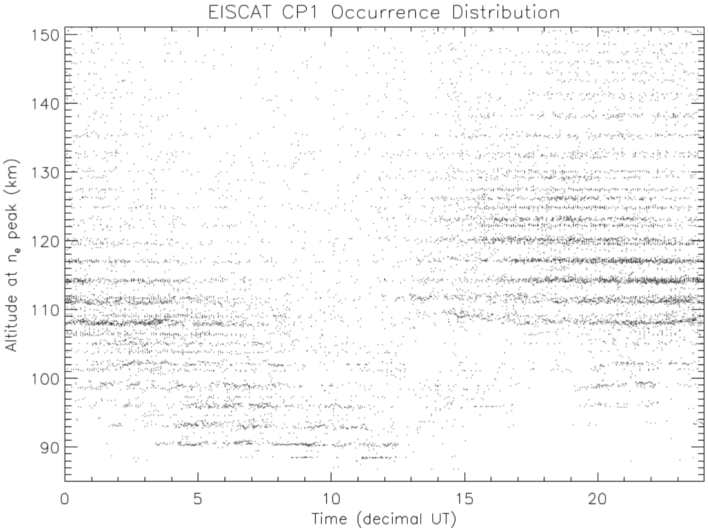
Other reasons for the different peak heights?





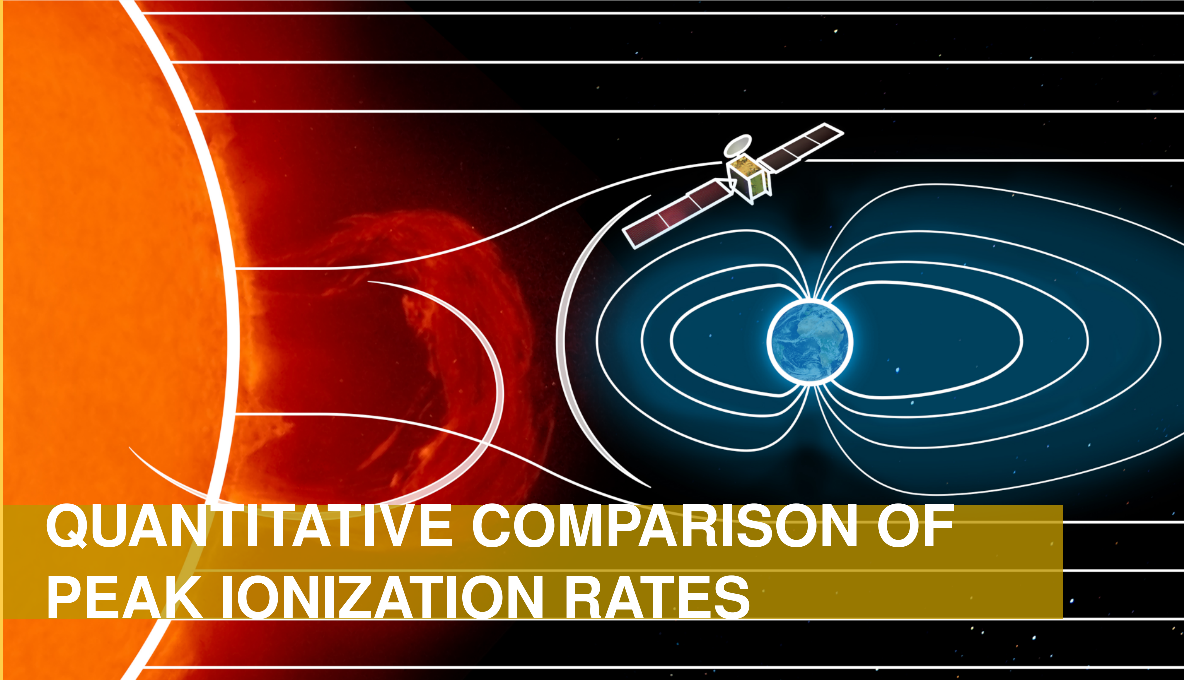
- no particle channel at 20 keV
- TED band 14 (6.503-9.457 keV) – mep0e1-e2 (30-100 keV)
- translates into altitude gap 96–108 km
- MLT difference: TED band 14 elevated at night. mep0e1-e2 peaks at 6 MLT.

Comparison to EISCAT (ionization, not rates)



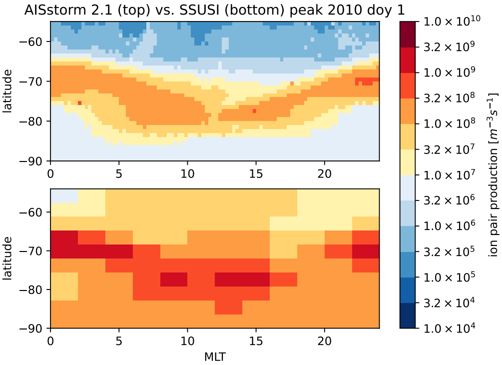
Bösinger et al. (Fig. 7 in 2004)

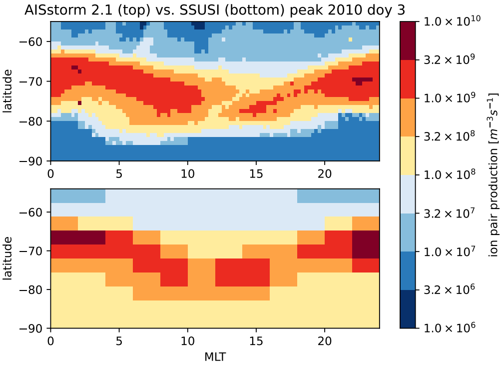
- SSUSI (data/model) ionization rate peaks are:
  - ✗ mostly at 100 km
  - (✓) between 15-19 MLT mostly at 105 km (higher altitude, probably p^+)
- AISstorm ionization rate peaks are
  - ✓ mostly at 110 km
  - (✓) between 9-13 MLT at about 100 km (lower altitude)



QUANTITATIVE COMPARISON OF PEAK IONIZATION RATES

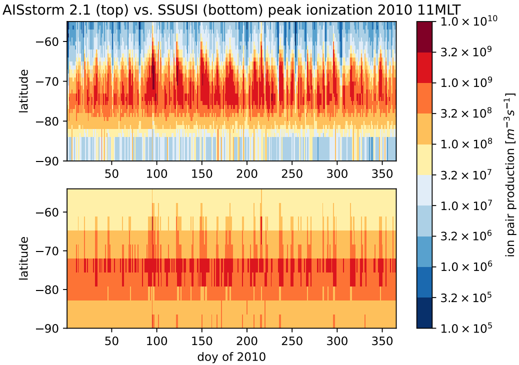
Quantitative comparison of peak ionization rates

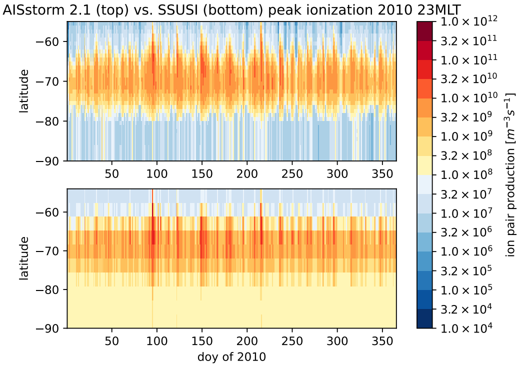




- As ionization altitudes differ, we compare the peak ionization independent from altitude.

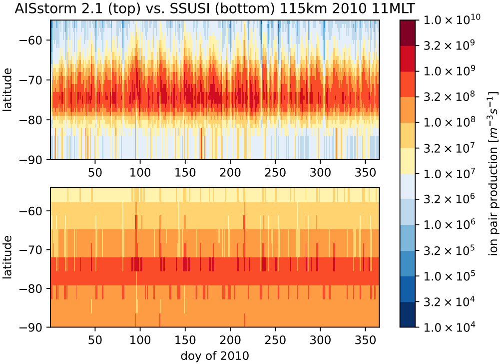
Quantitative comparison of peak ionization rates - long term

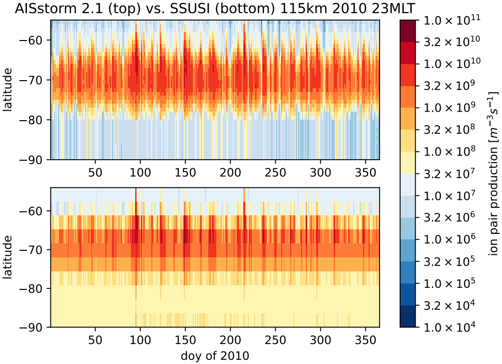




- at individual peak altitude
- note: different color scale

Comparison of spatial auroral pattern - long term





- at 115 km, repetition

Summary

- latitudinal and MLT distribution similar
- SSUSI shows more ionization in polar and subauroral latitudes
- dynamical range of AISstorm seems to be larger
- vertical:
  - peak altitudes and slopes differ
  - slope and part of the altitude differences can be attributed to energy deposition algorithm but not all
  - energy gap between TED and MEPED may be an issue
  - AISstorm ionization altitude agrees better to EISCAT
  - both data sets qualitatively show altitude variations with MLT that are covered by EISCAT
- peak auroral ionization rates independent of altitude agree mostly between AISstorm and SSUSI

Thank you for listening!

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