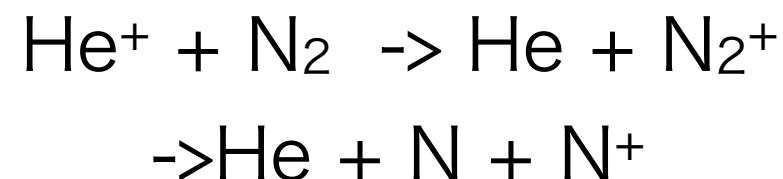


# 共鳴散乱光で見る上部電離圏のHe イオン分布

穂積裕太(京大)、齊藤昭則(京大)、吉川一郎(東京大)、  
山崎敦(ISAS/JAXA) 村上豪(ISAS/JAXA)

# 上部電離圏でのHeイオン

- 昼間側でphoto-ionizationで生成され、400km以下の窒素分子との衝突で消滅する。
- 互いに荷電交換するOイオン、Hイオンに対して、Heイオンはそれらと荷電交換反応を行わず、比較的、化学的に安定で長寿命と言える。
- したがって、熱圏におけるDynamicsの影響を受けやすく、その指標として優れている。



total rate coefficient  $1.2 \times 10^{-9} \text{ cm}^3\text{s}^{-1}$  (Ferguson, 1970)

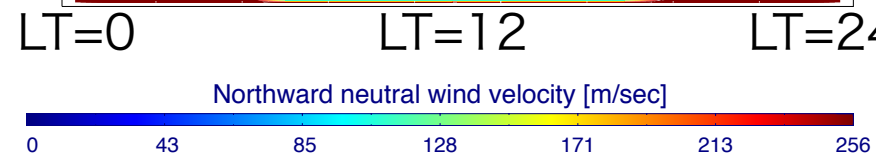
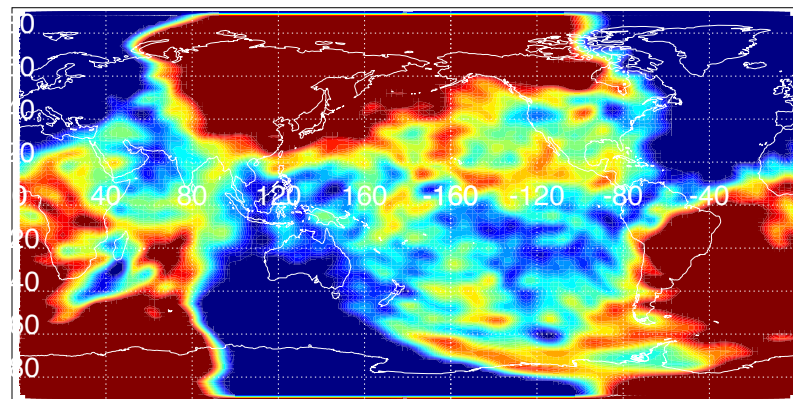
# Previous Works

- In-situ measurements of several satellites have provided some characteristic of He<sup>+</sup> structure in the topside ionosphere. (ex., H.A. Taylor. Jr. 1971, the winter bulge )
- R.J. Moffett and W.B. Hanson 1972 and J.A. Murphy et al. 1984 explained these He<sup>+</sup> structure with numerical models.
- However, examination for theory with observational data is not perfectly done because of limitations of in-situ measurements.
- Altitude change of a satellite along its orbit cause difficulty in getting precise horizontal structure at fix altitude.
- The movement of orbital plane of polar orbit satellite prevent getting seasonal dependence at fix local time.

# 熱圏の風 (GAIA)

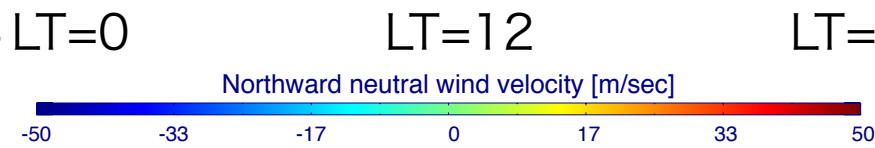
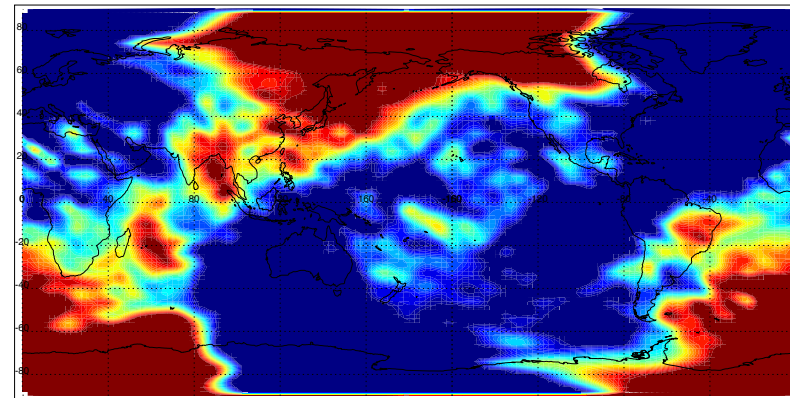
20130322

ginvv20130322cpl.nc height=300 time= 0.50



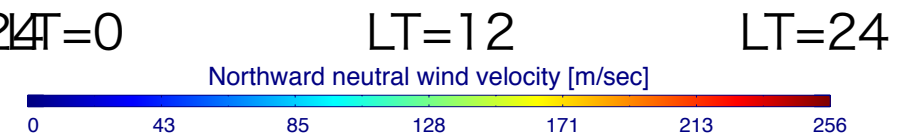
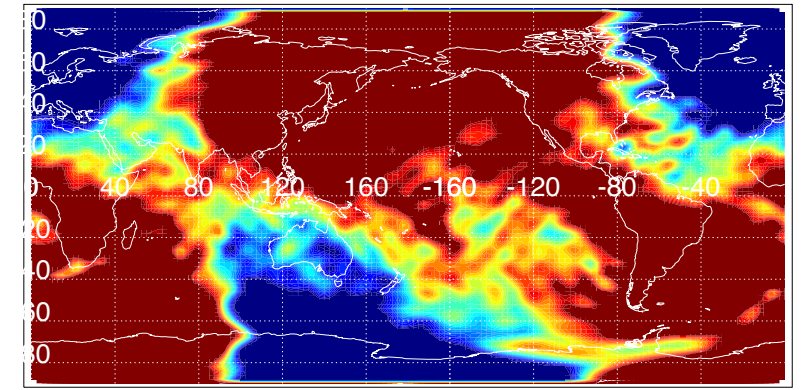
20130622

ginvv20140622cpl.nc height=300 time= 0.25



20131221

ginvv20131221cpl.nc height=300 time= 0.25





# December solstice

North

Equator

South

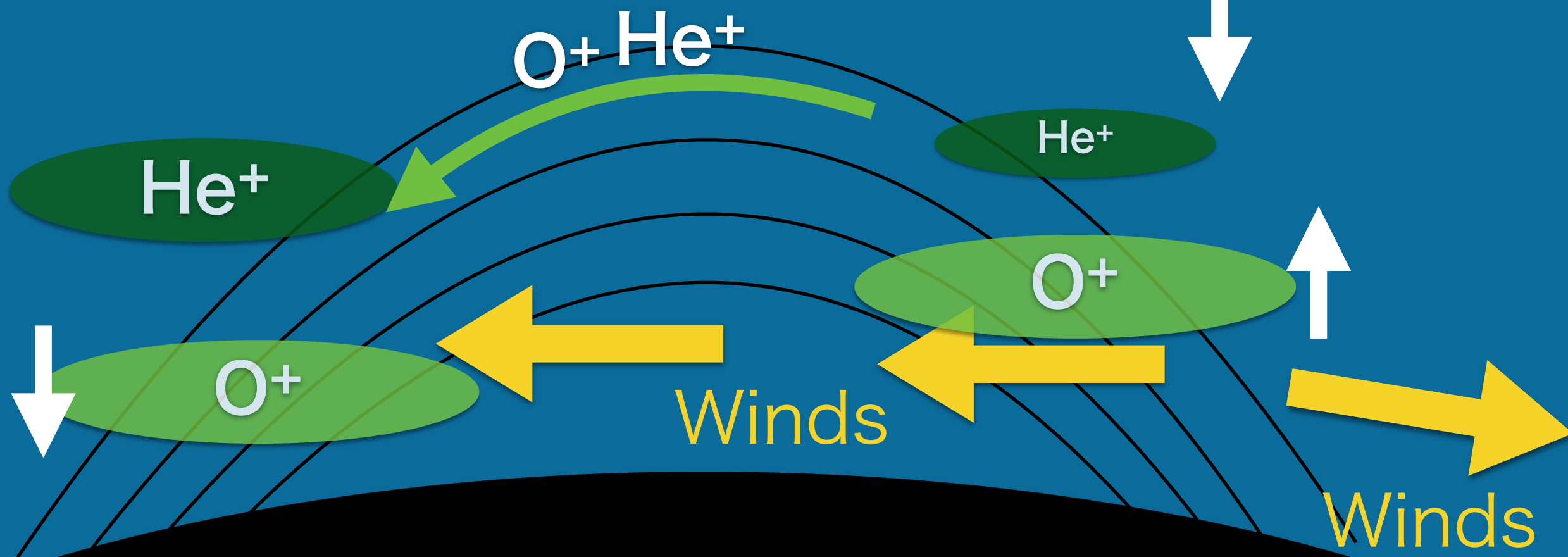
The momentum transfer collision frequencies are, in  $s^{-1}$  with  $N$  and  $n$  in  $cm^{-3}$   
(BANKS, 1966; SCHUNK and WALKER, 1970)

$$\text{He}^+ - \text{O}^+: \nu_{14} = 1.3 \times 10^{-5} (T_i/1000)^{-3/2} N_4$$

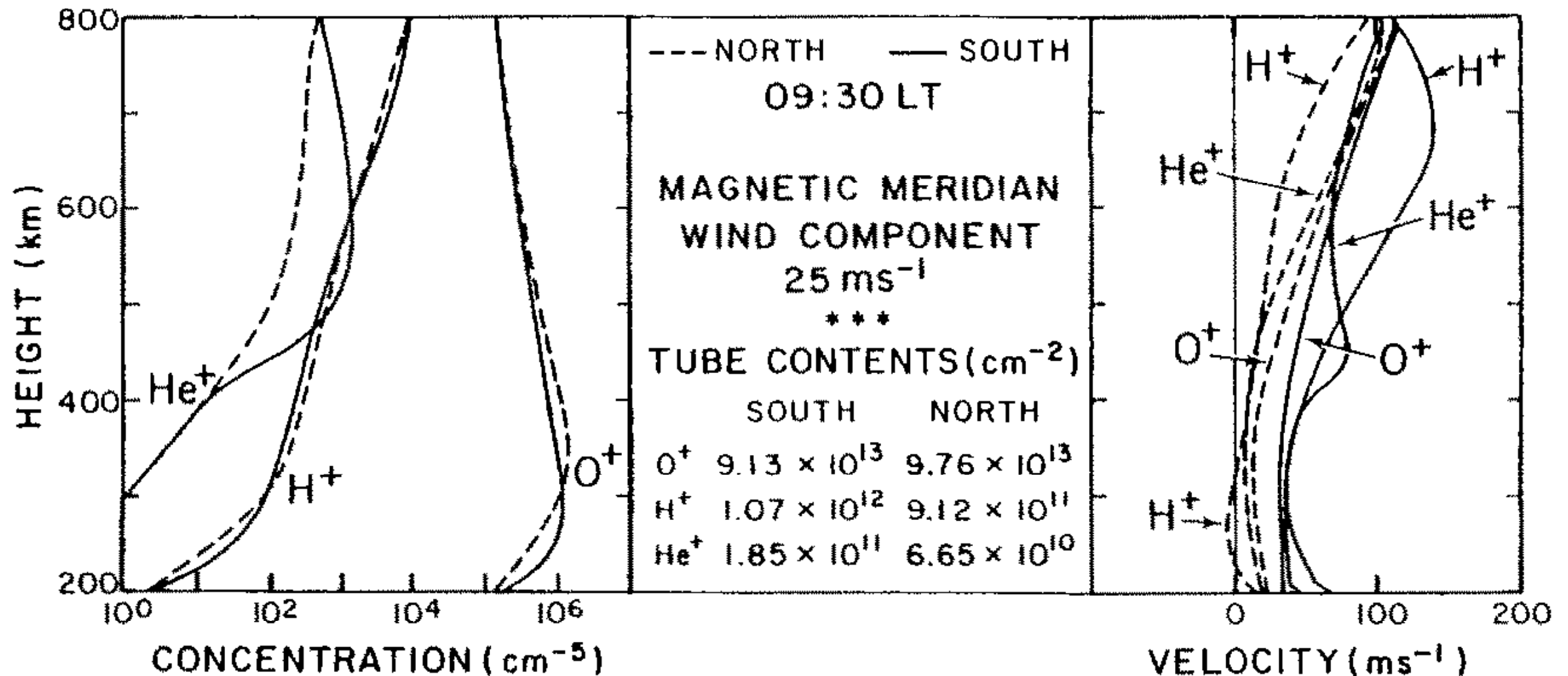
$$\text{He}^+ - \text{H}^+: \nu_{13} = 6.3 \times 10^{-6} (T_i/1000)^{-3/2} N_3$$

$$\text{He}^+ - \text{O}: \nu_{10} = 1.4 \times 10^{-9} (T_i/1000)^{1/2} n(\text{O})$$

Sub-solar point



# Previous Work



The calculated distribution of ion concentrations to examined  
the the influence of neutral winds  
the deffrence is ~3 [Murphy et al. 1984]

# The scope of this study

- Resonant scattering of He<sup>+</sup> at 30.4 nm observed from the ISS is utilized to analyze the horizontal structure of total helium content.
- With this new data, that is different from in-situ data, we examine our understanding of the dynamics of He<sup>+</sup> in the topside ionosphere.



## Extreme Ultra Violet Imager (EUVI)

Resonant scattering:

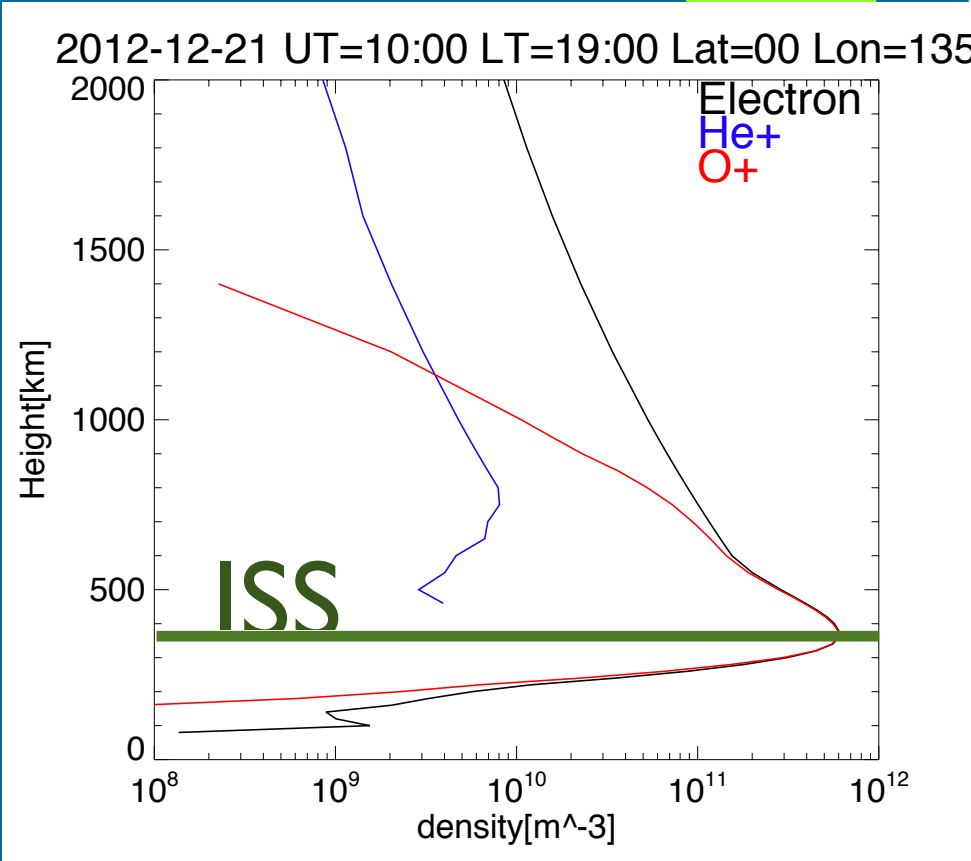
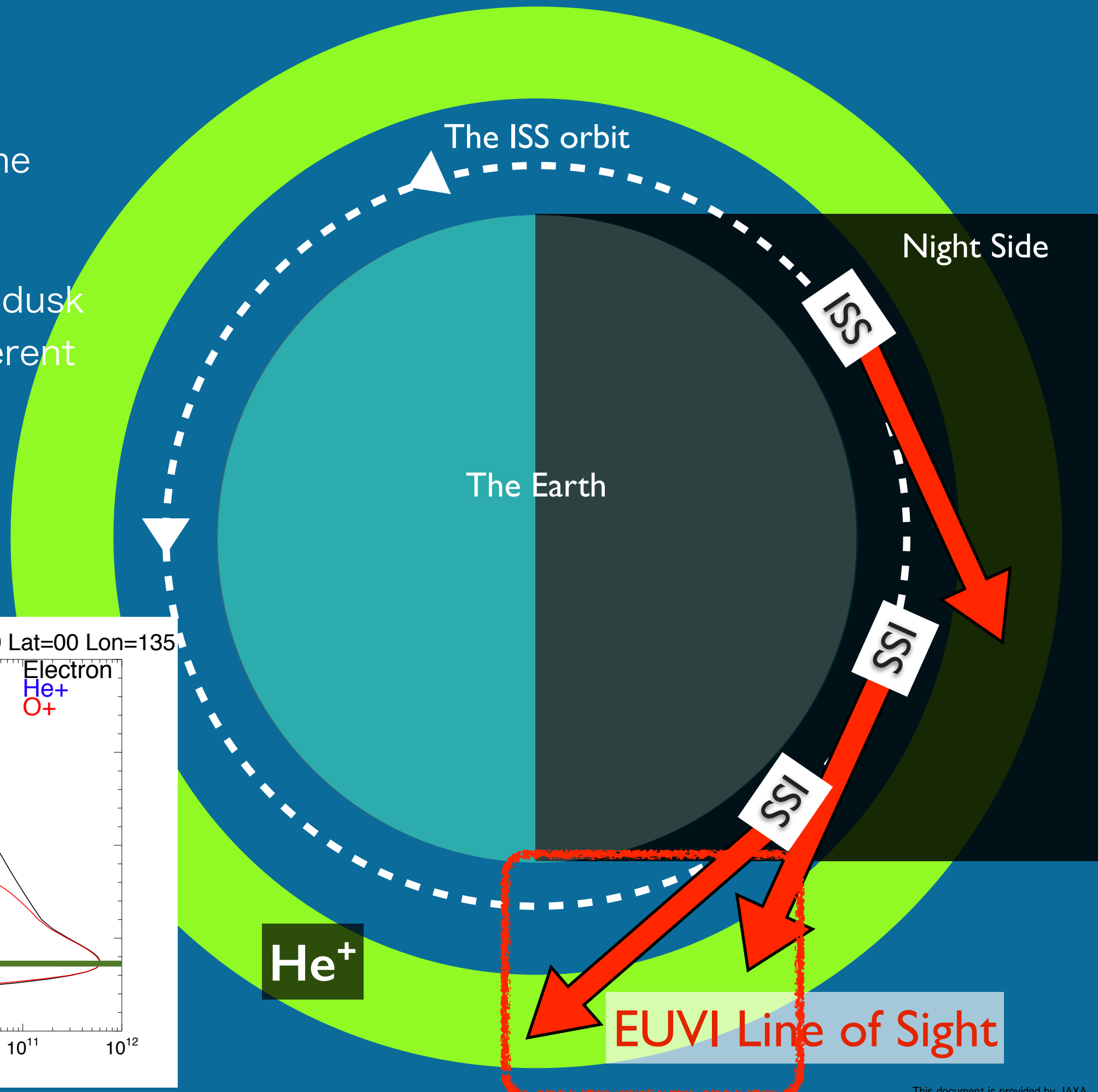
83.4nm (O<sup>+</sup>) 30.4nm (He<sup>+</sup>)

Limb observation in backward.

FOV 13.2 deg.



- EUVI observes in the night side.
- He+ distribution in dusk sector in each different longitude can be observed.

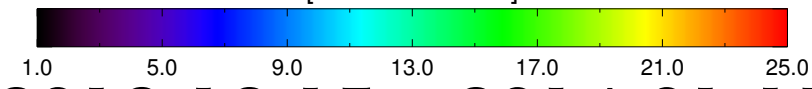
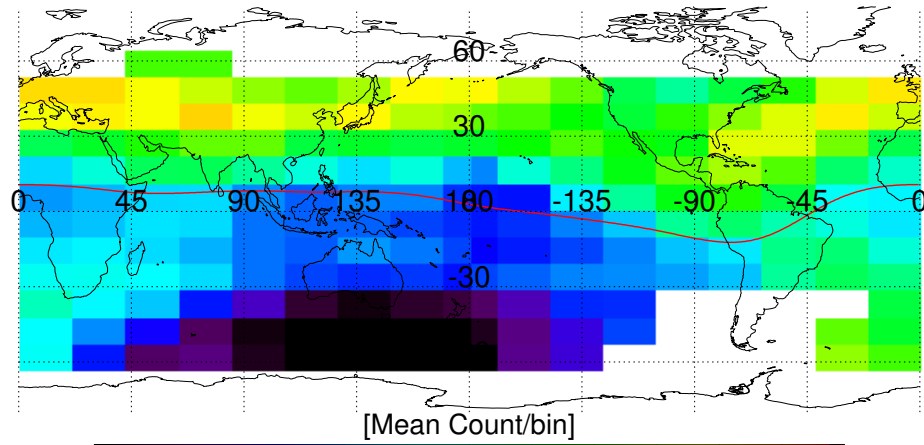


- 高度800kmを中心にHeイオン層が存在すると仮定し、高度800kmに観測されたデータをマッピングする。
- ISSの太陽軌道面が半周する1ヶ月のデータを足し合わせることで北緯南緯60°の範囲をカバーできる。
- 緯度10°、経度20°でビンニング。
- 太陽天頂角90°-110°の範囲のデータのみ解析する。
- オーロラの影響を避けるため磁気緯度45°以上かつAE指数45°のデータは除く。
- 中性大気による吸収の影響をさけるためタンジェンシャルポイントの高度が300 km以上のピクセルのデータのみ解析する。
- TIMED衛星のSEEによる太陽光30.5 nmの観測データを用いて補正する。カウントに $F_{\text{day}}/F_{\text{mean}}$ を掛ける。(F<sub>day</sub>は観測された日のフラックス、F<sub>mean</sub>は足し合わせる期間中の平均のフラックス)

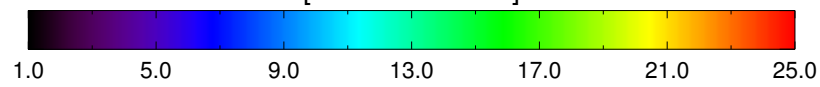
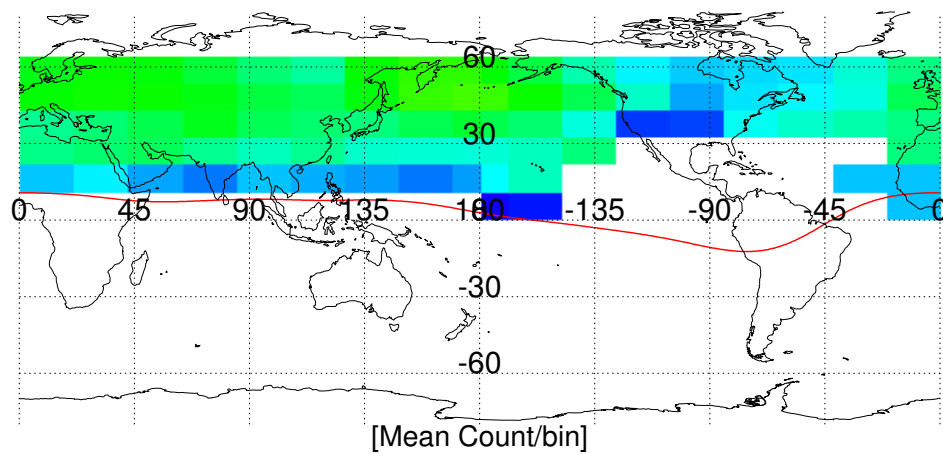


# December solstice

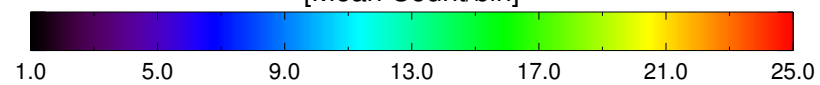
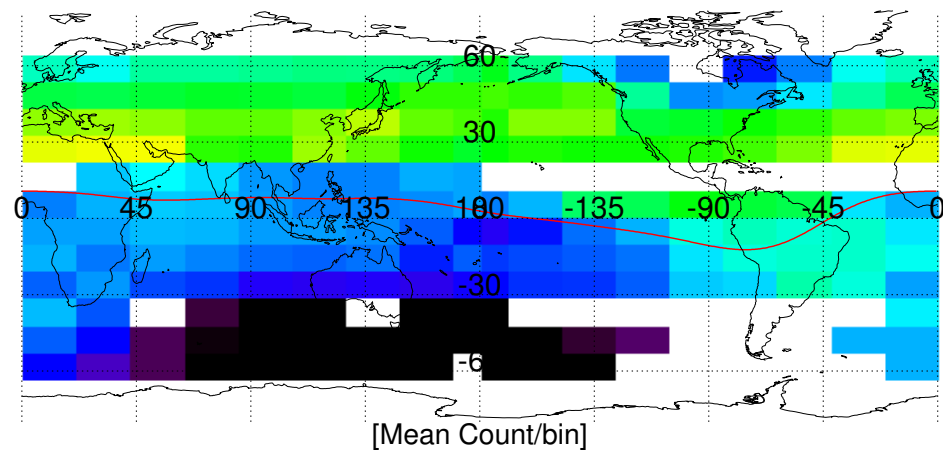
2013-11-15 ~ 2013-12-15



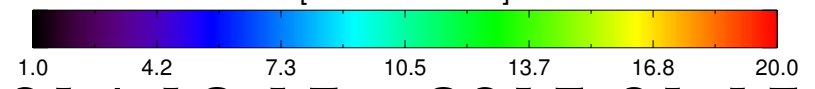
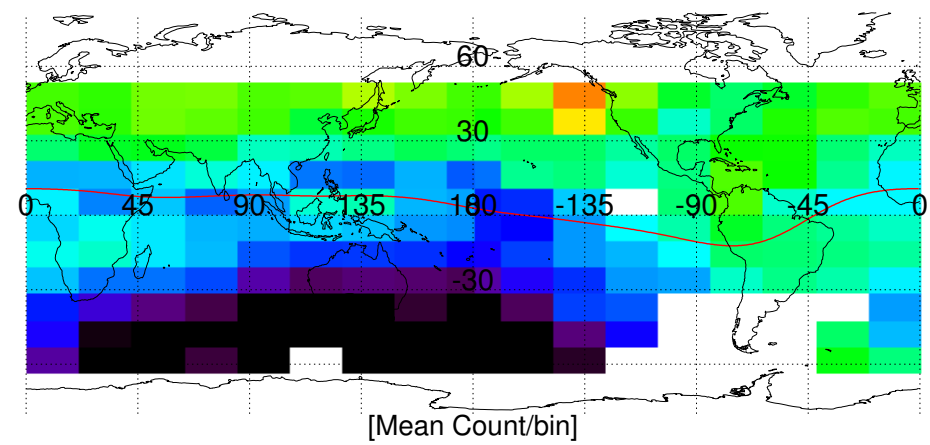
2013-12-15 ~ 2014-01-15



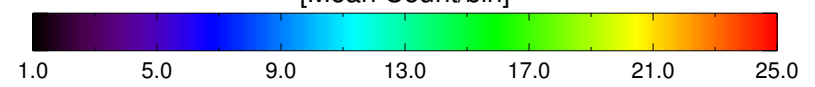
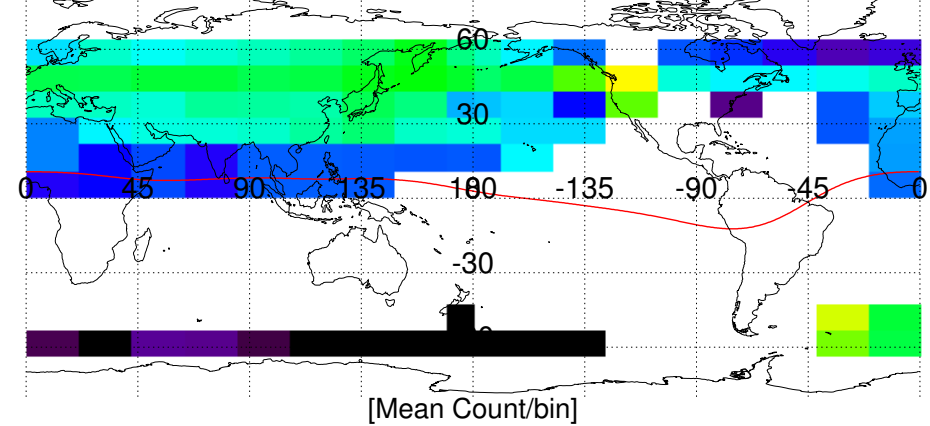
2014-01-15 ~ 2014-02-15



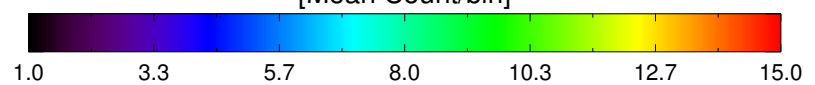
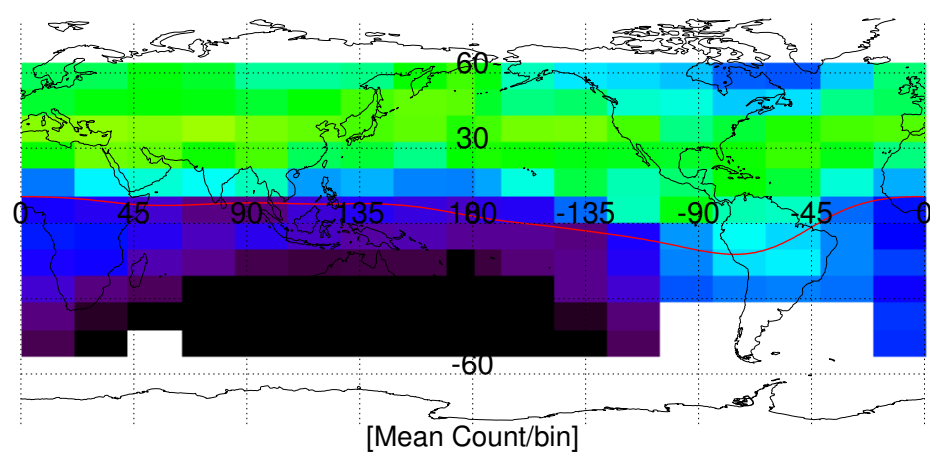
2014-11-15 ~ 2014-12-15



2014-12-15 ~ 2015-01-15

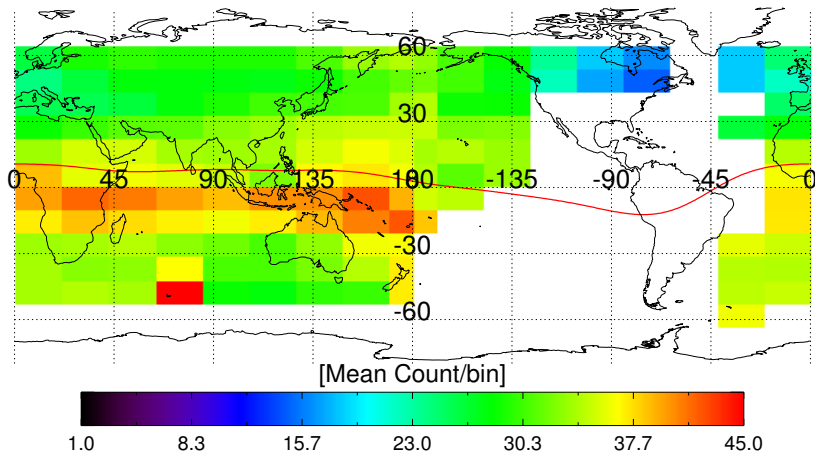


2015-01-15 ~ 2015-02-15

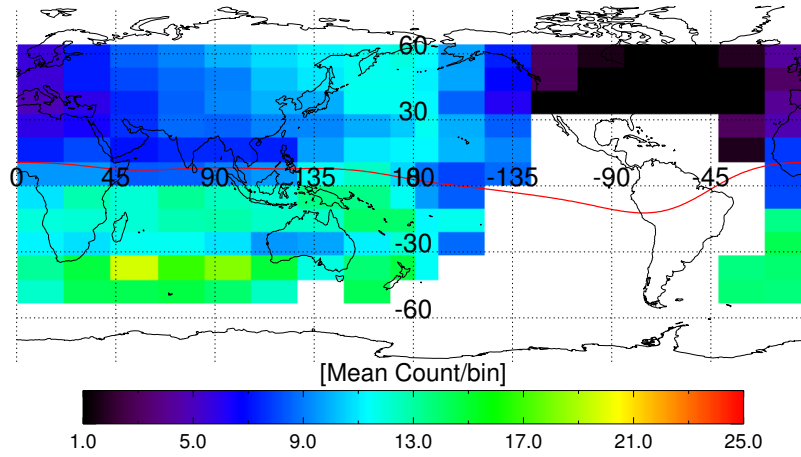


# June solstice

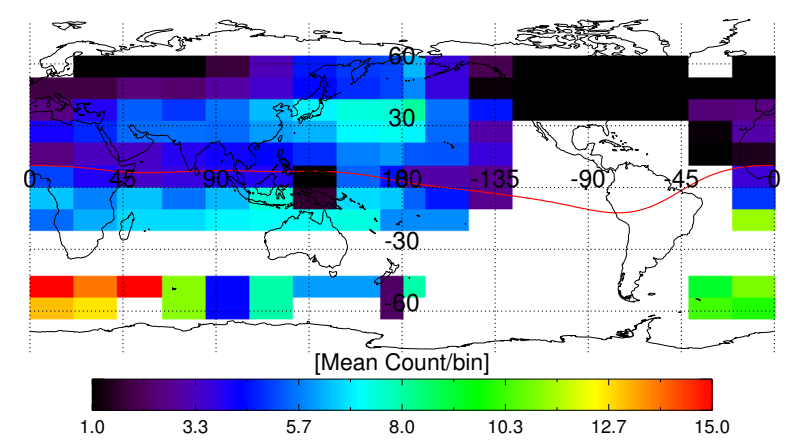
2013-04-15~2013-05-15



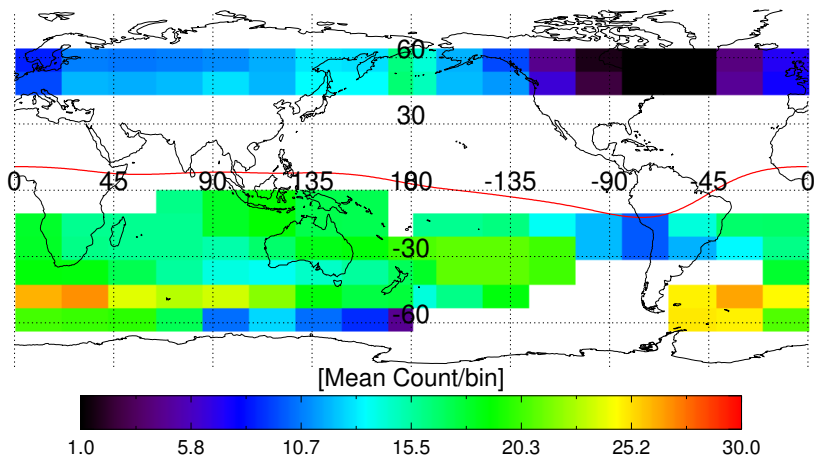
2014-04-15~2014-05-15



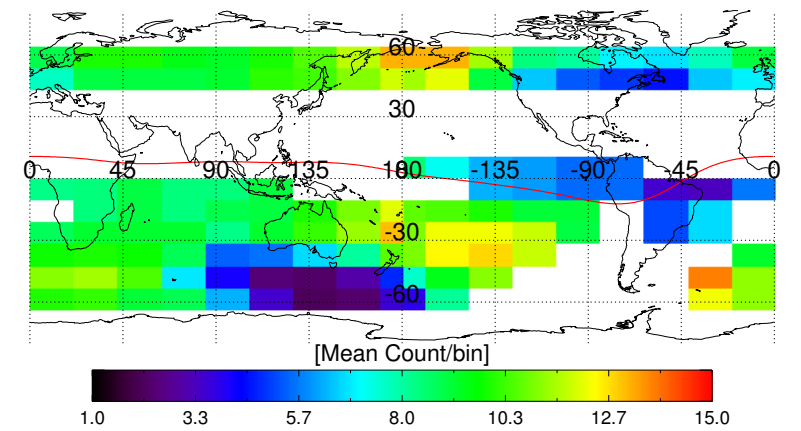
2015-04-15~2015-05-15



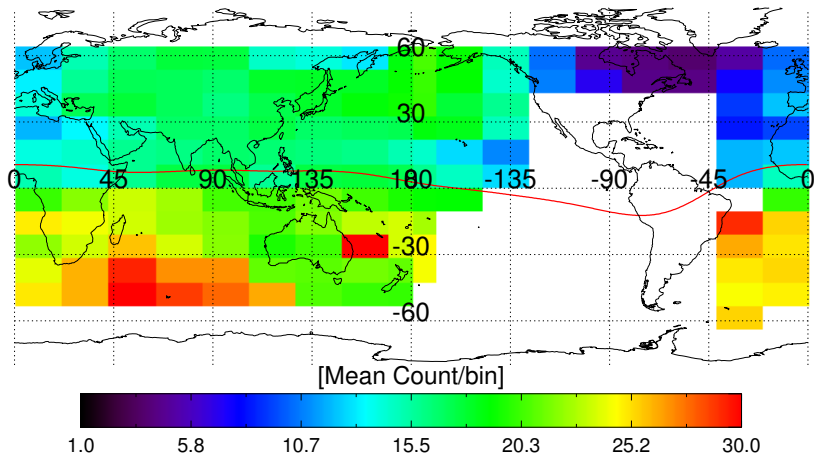
2013-05-15~2013-06-15



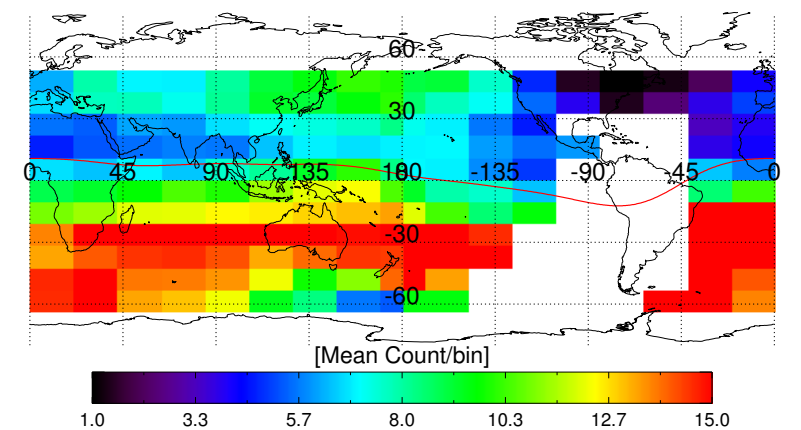
2015-05-15~2015-06-15



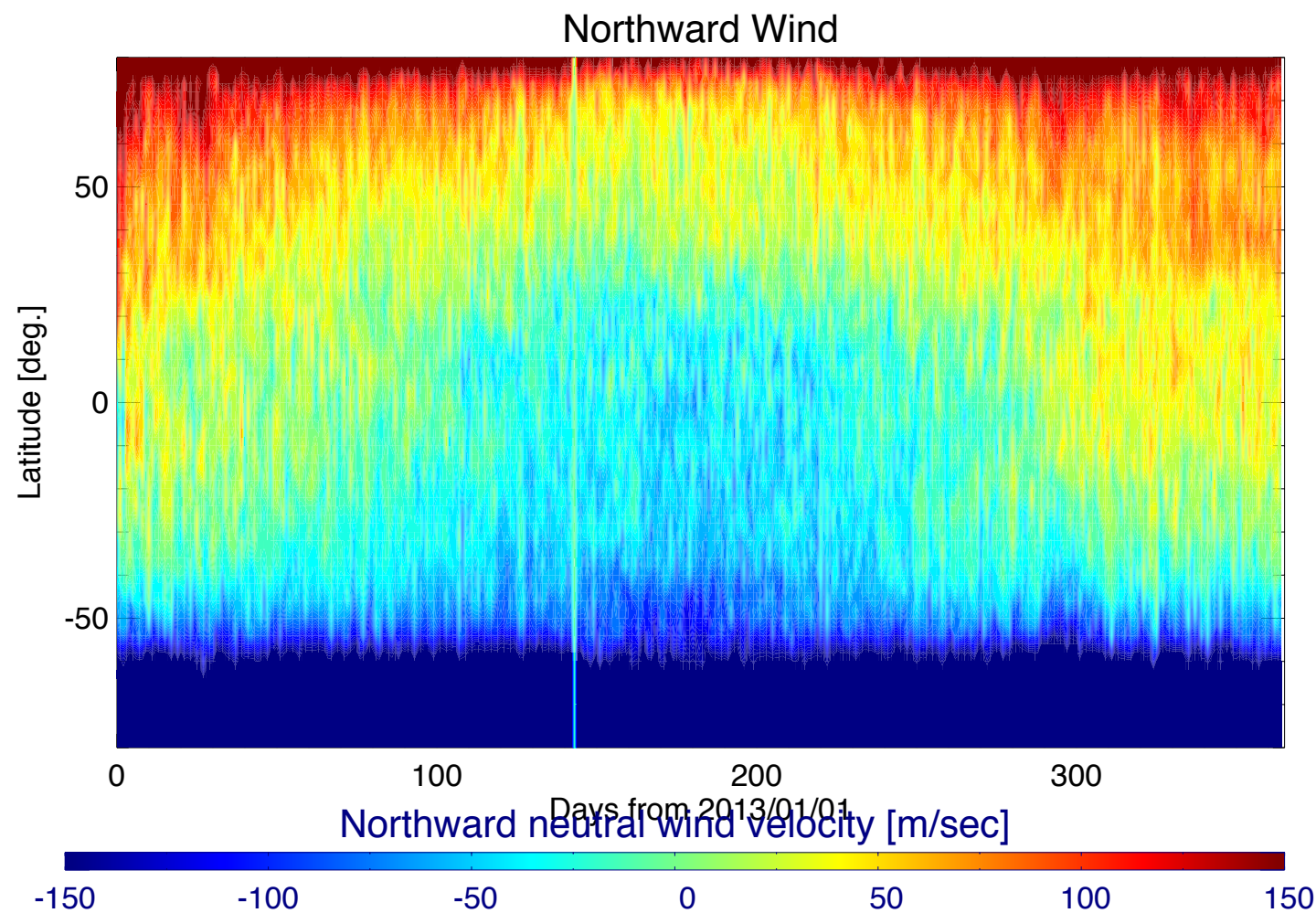
2013-06-15~2013-07-15



2015-06-15~2015-07-15





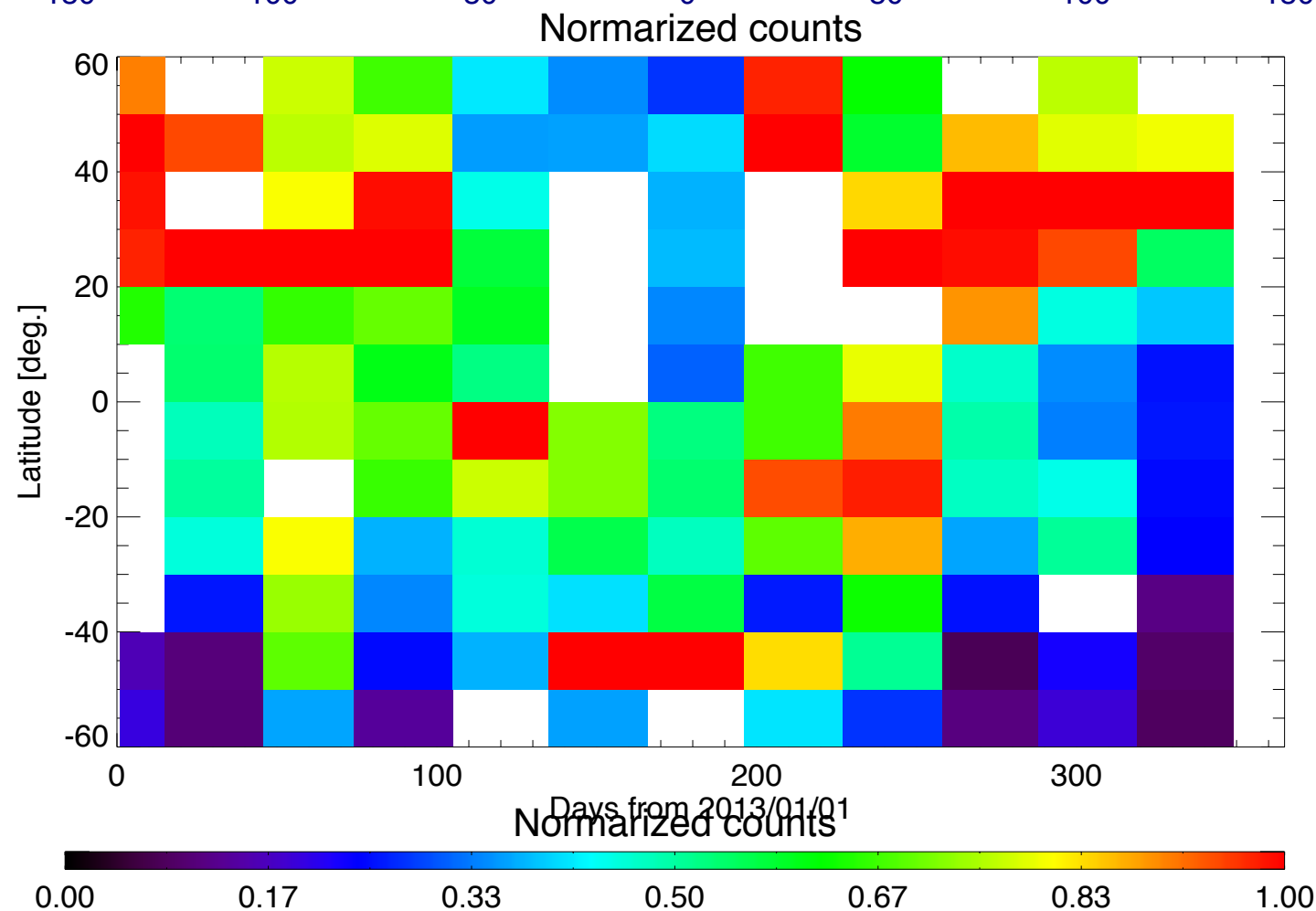


GAIA

経度 90°、LT=12

高度300 kmにおける

南北風



EUVI

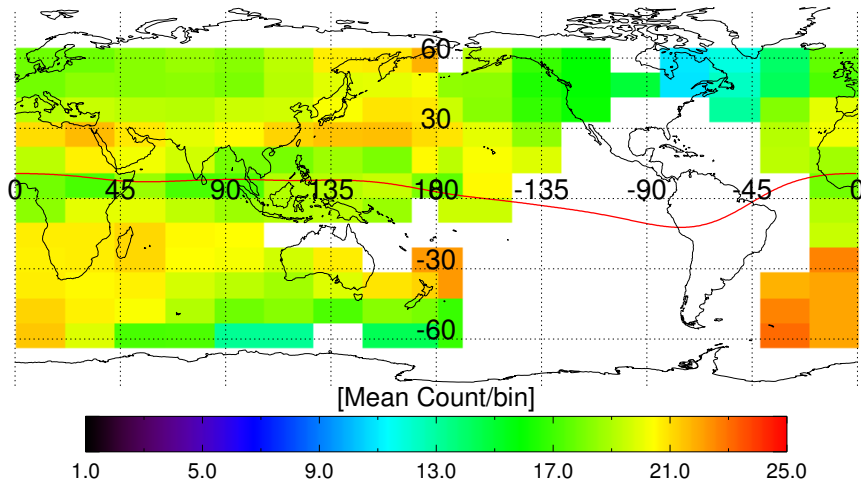
経度 90°、LT=19付近

カウントを1ヶ月毎に

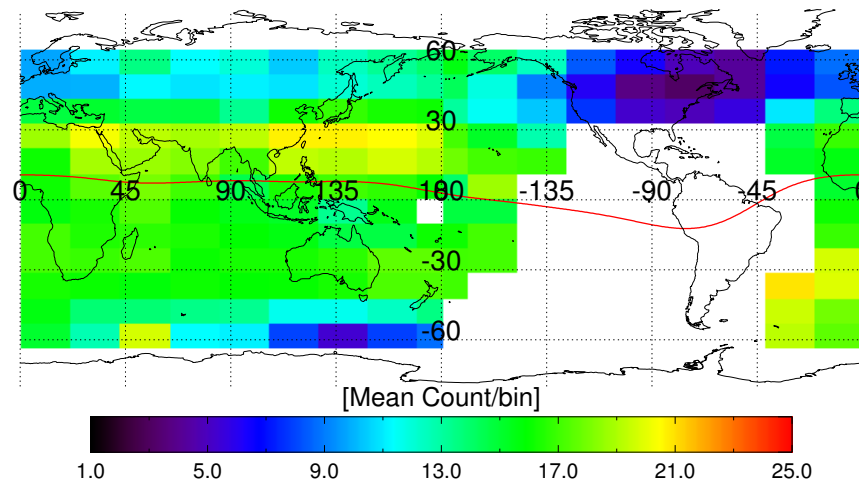
規格化

# March Equinox

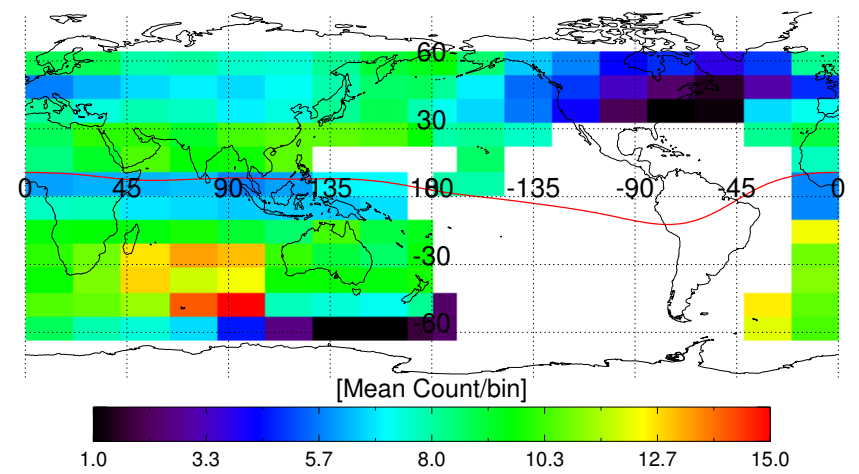
2013-02-15~2013-03-15



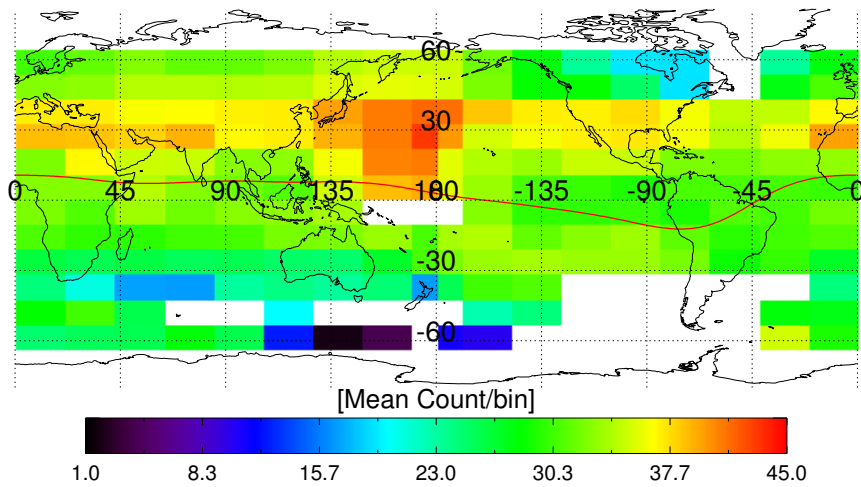
2014-02-15~2014-03-15



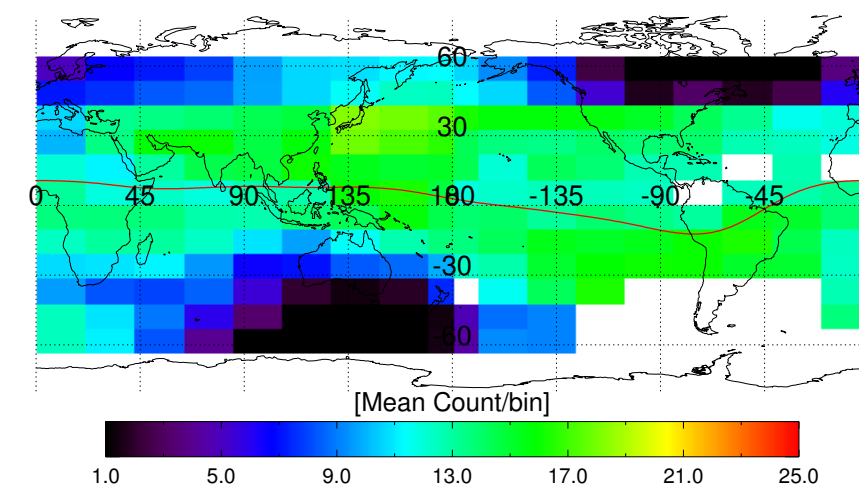
2015-02-15~2015-03-15



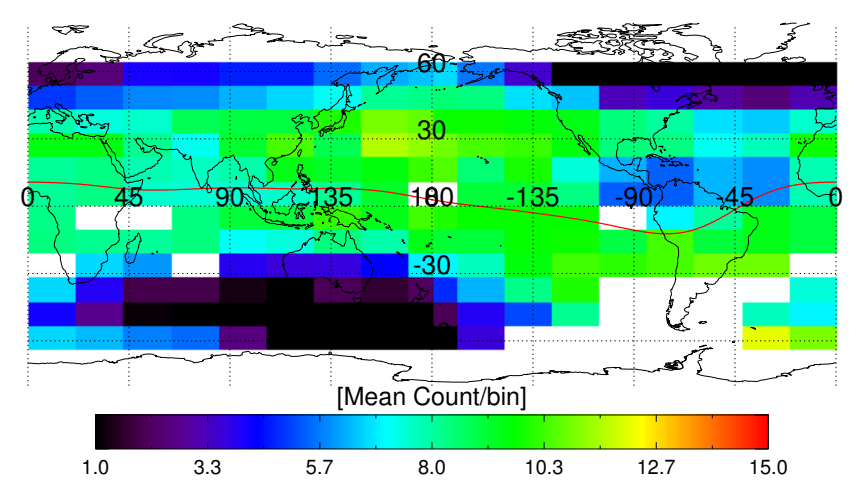
2013-03-15~2013-04-15



2014-03-15~2014-04-15

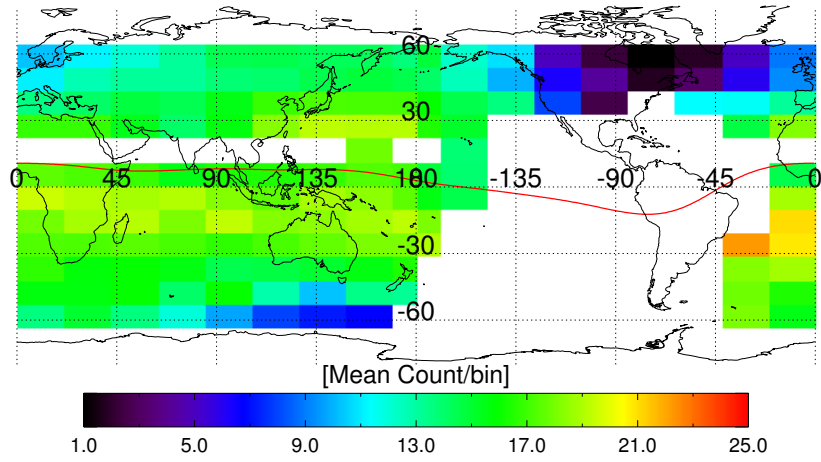


2015-03-15~2015-04-15

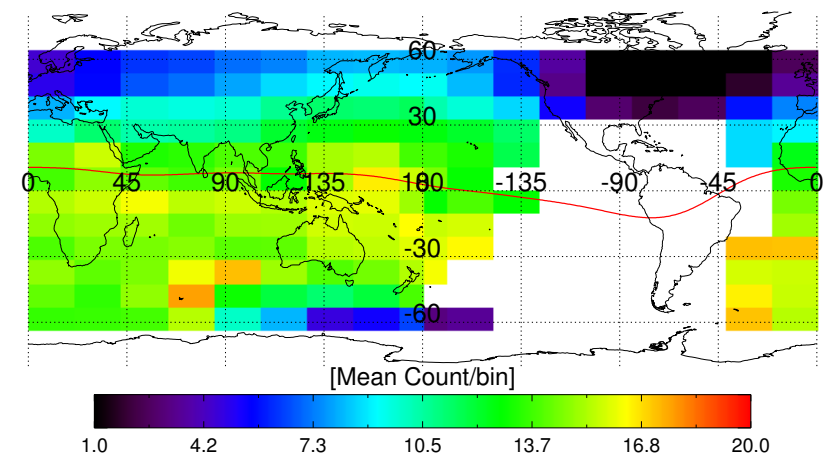


# September Equinox

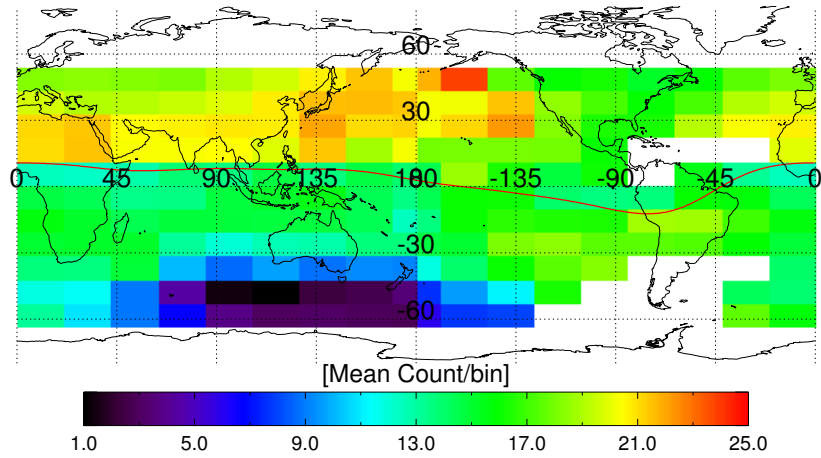
2013-08-15~2013-09-15



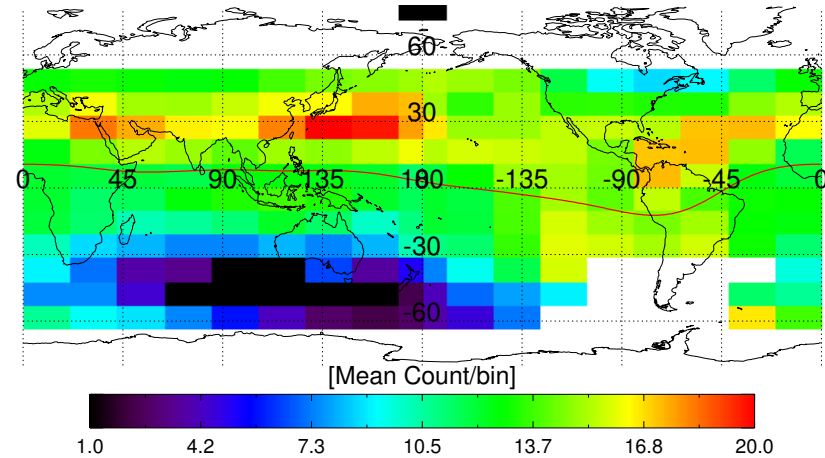
2014-08-15~2014-09-15



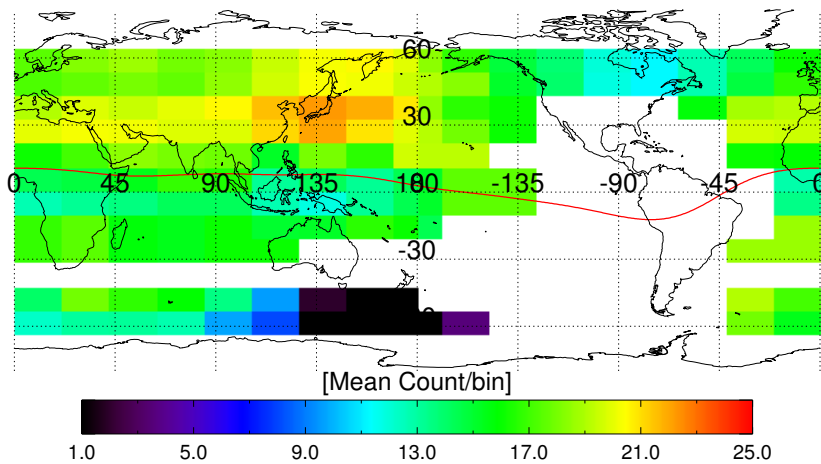
2013-09-15~2013-10-15



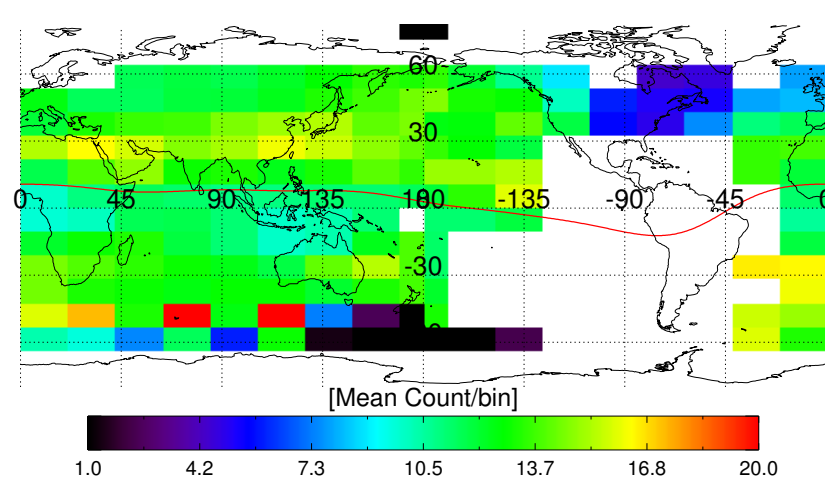
2014-09-15~2014-10-15



2013-10-15~2013-11-15



2014-10-15~2014-11-15



# Comparison with SAMI-2 model

SAMI2 model

電離圏の数値モデル

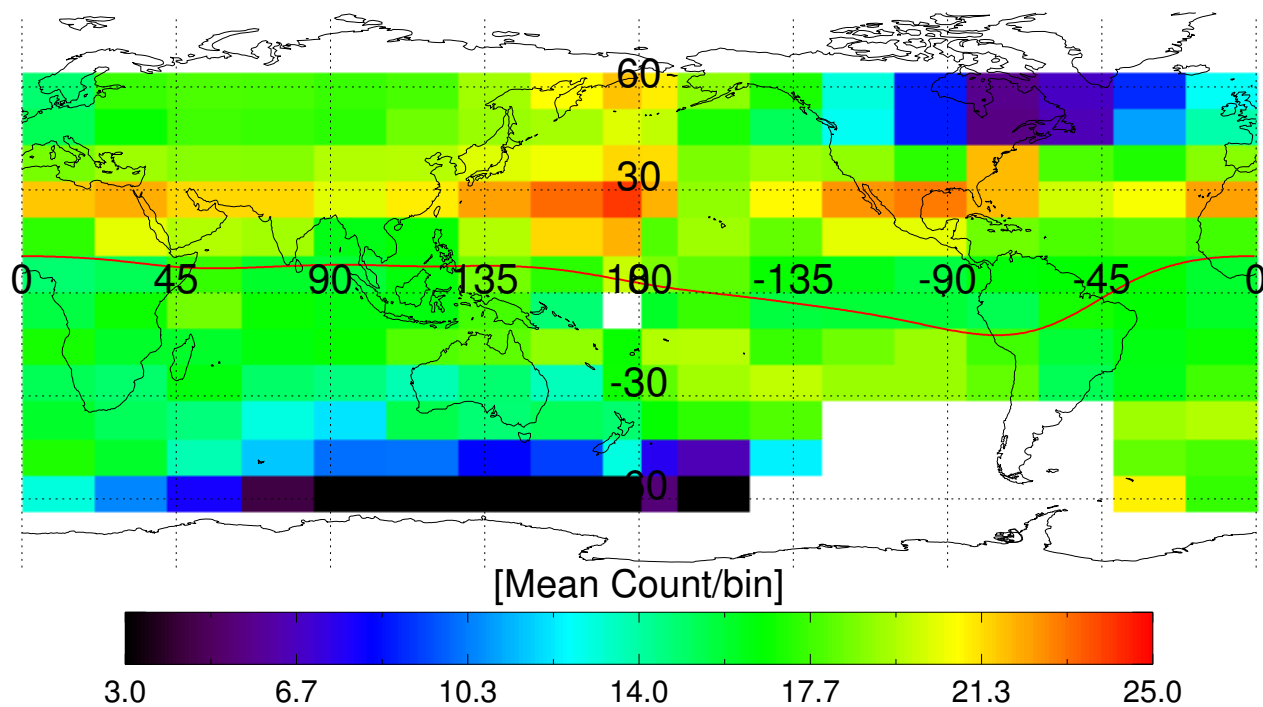
経度15度毎で計算

各経度毎、60の磁力線、磁力線にそって201点について解く。

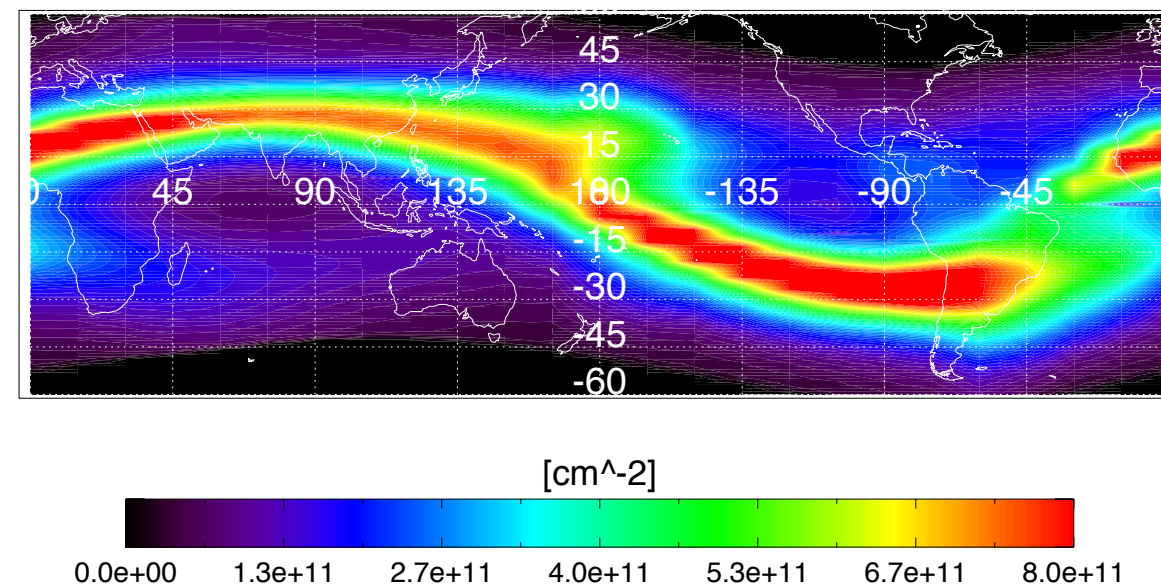
ローカルタイム0時から計算をはじめて、42時間後の結果について各点でのHeイオンの鉛直積分値を求めた。



2013-02-20 ~ 2013-04-20



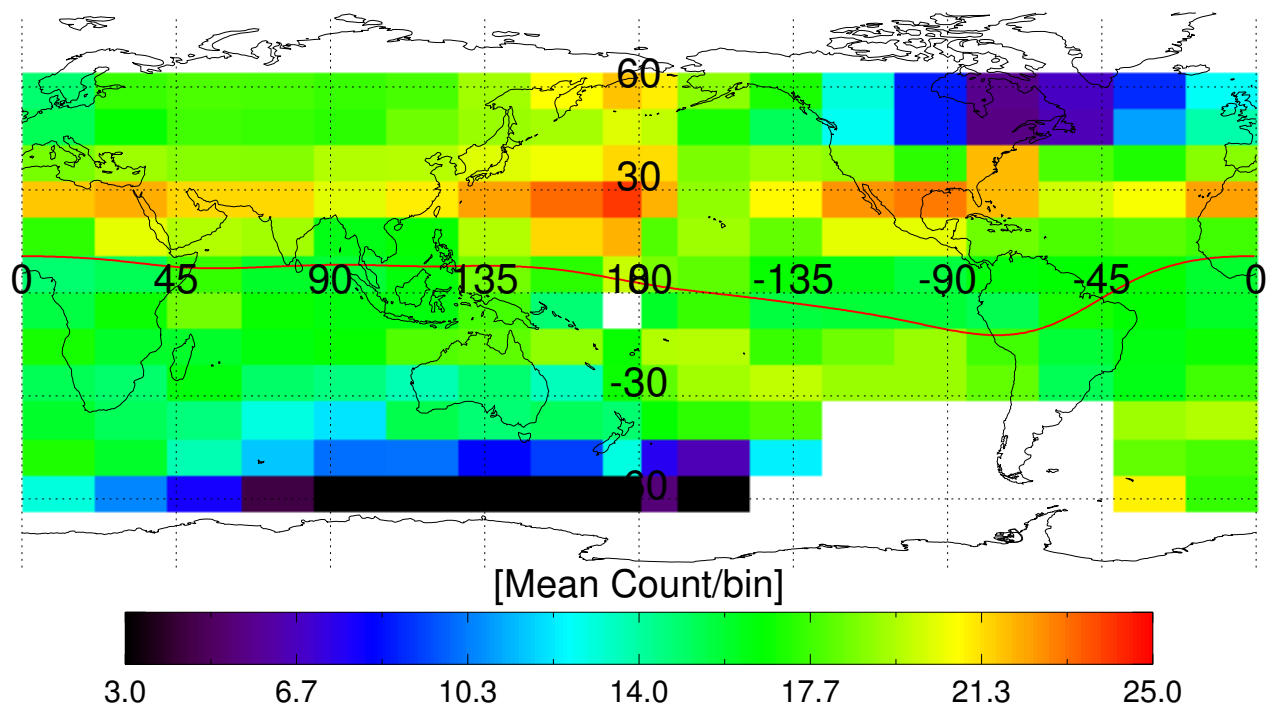
SAMI2 2013-03-20



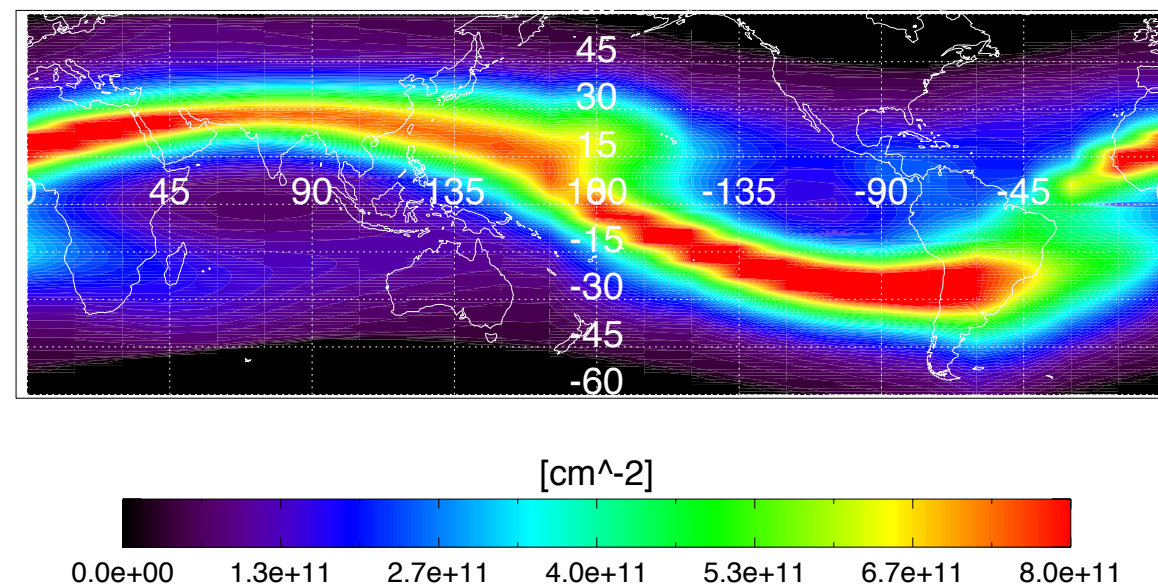
HFM93 wind model (Empirical model) may not be valid.

GAIA (Ground-to-topside model of Atmosphere and Ionosphere for Aeronomy) is an Earth's atmosphere-ionosphere coupled model that treats seamlessly the neutral atmospheric region from the troposphere to the thermosphere as well as the thermosphere-ionosphere interaction including the electrodynamics self-consistently.

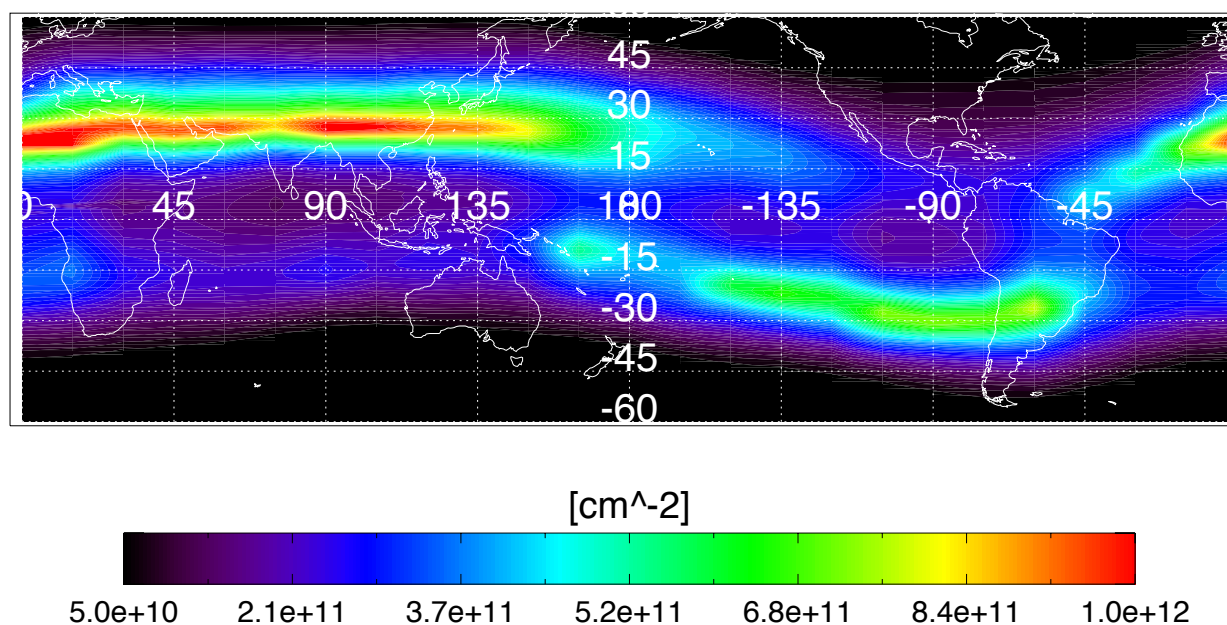
2013-02-20 ~ 2013-04-20



SAMI2 2013-03-20



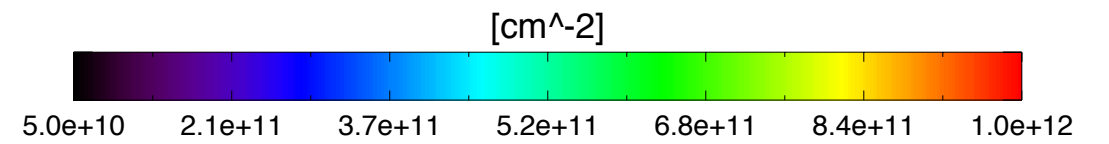
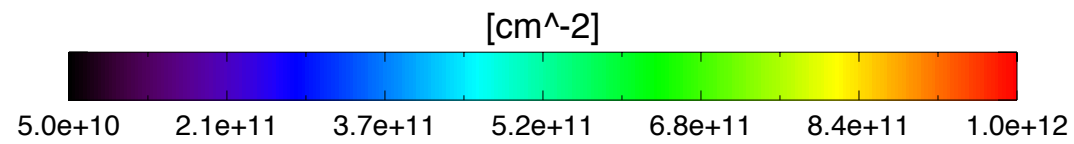
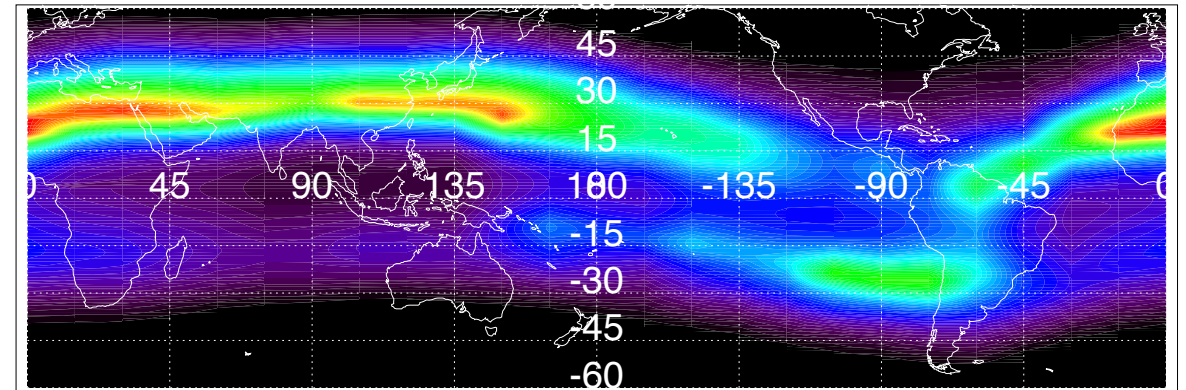
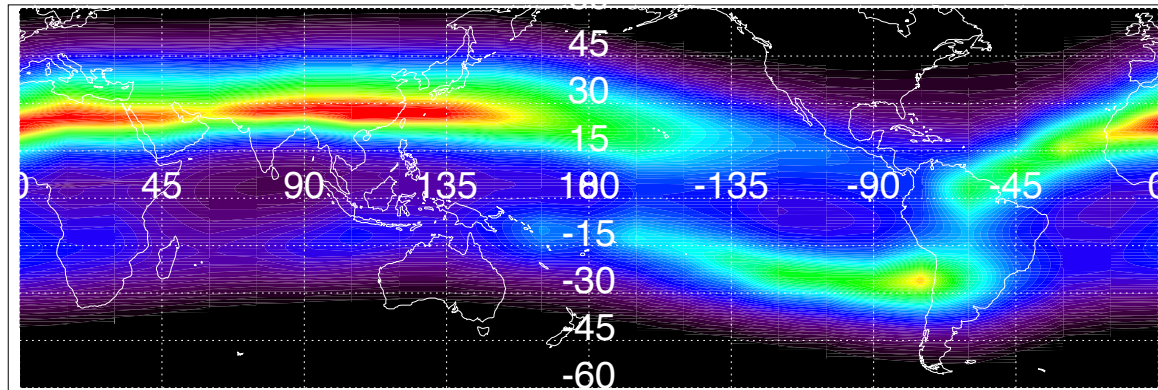
SAMI2+GAIA 2013-03-21





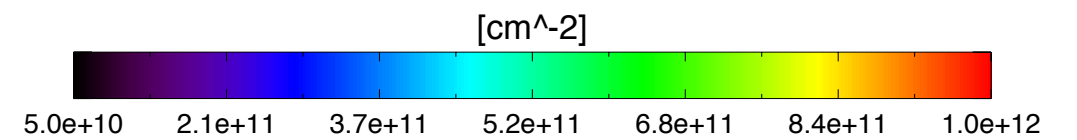
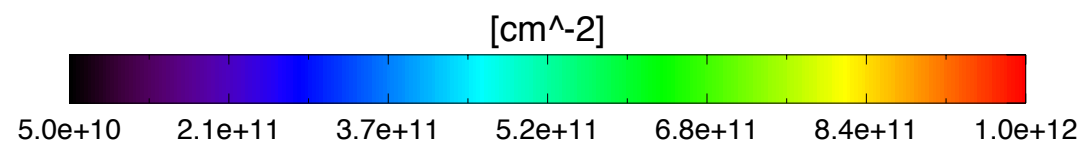
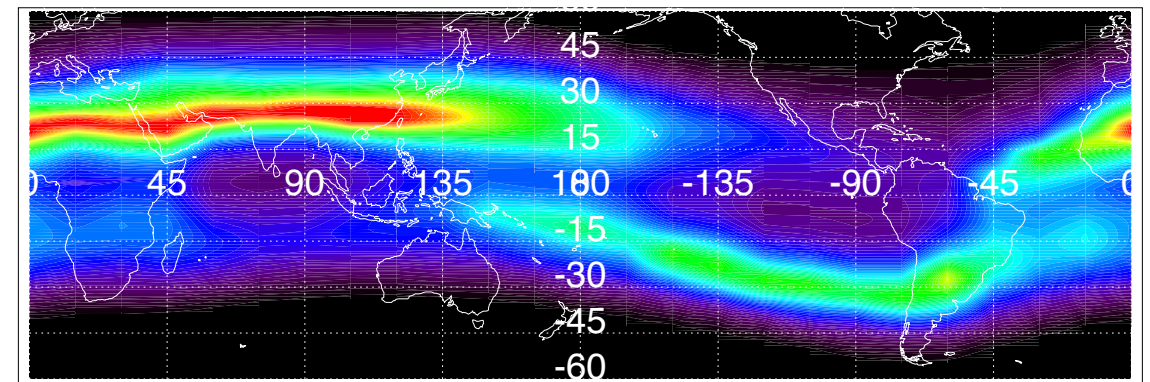
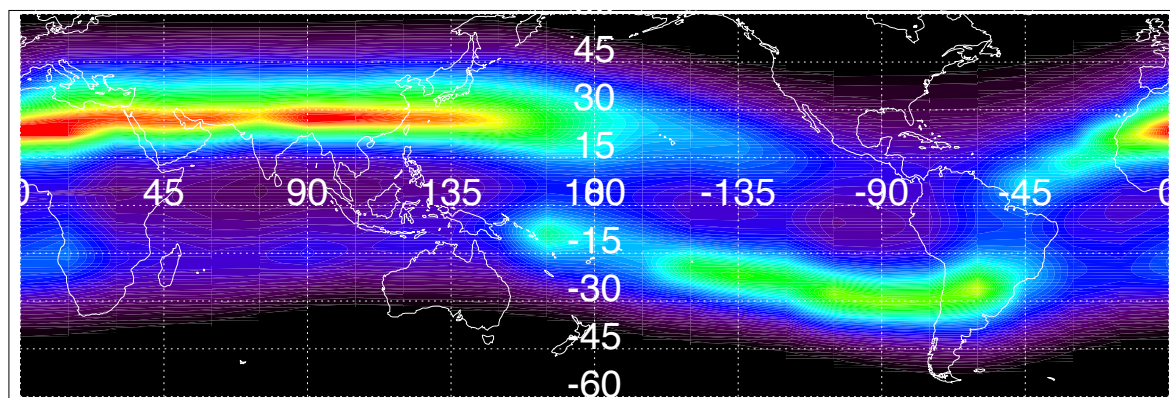
SAMI2 Result Local time Total He ion content 2013-03-15 LT = 18

SAMI2 Result Local time Total He ion content 2013-03-08 LT = 18

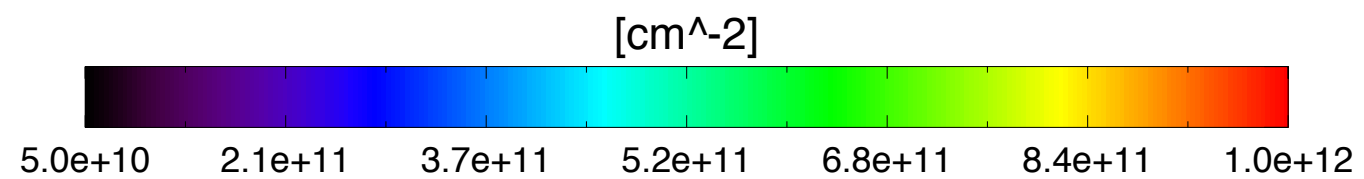
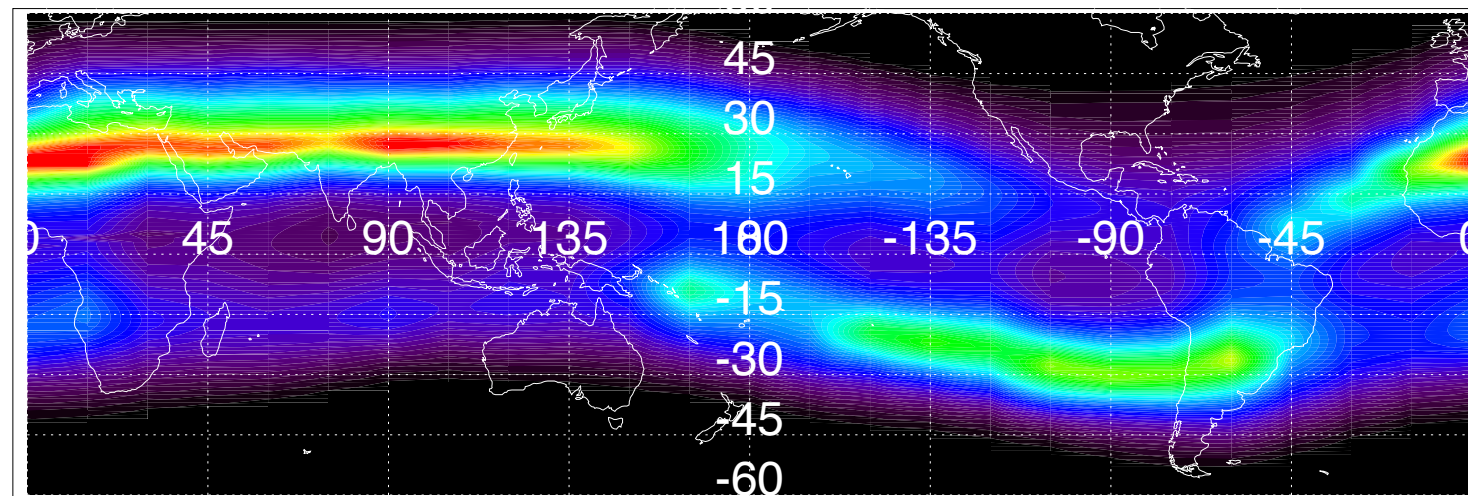
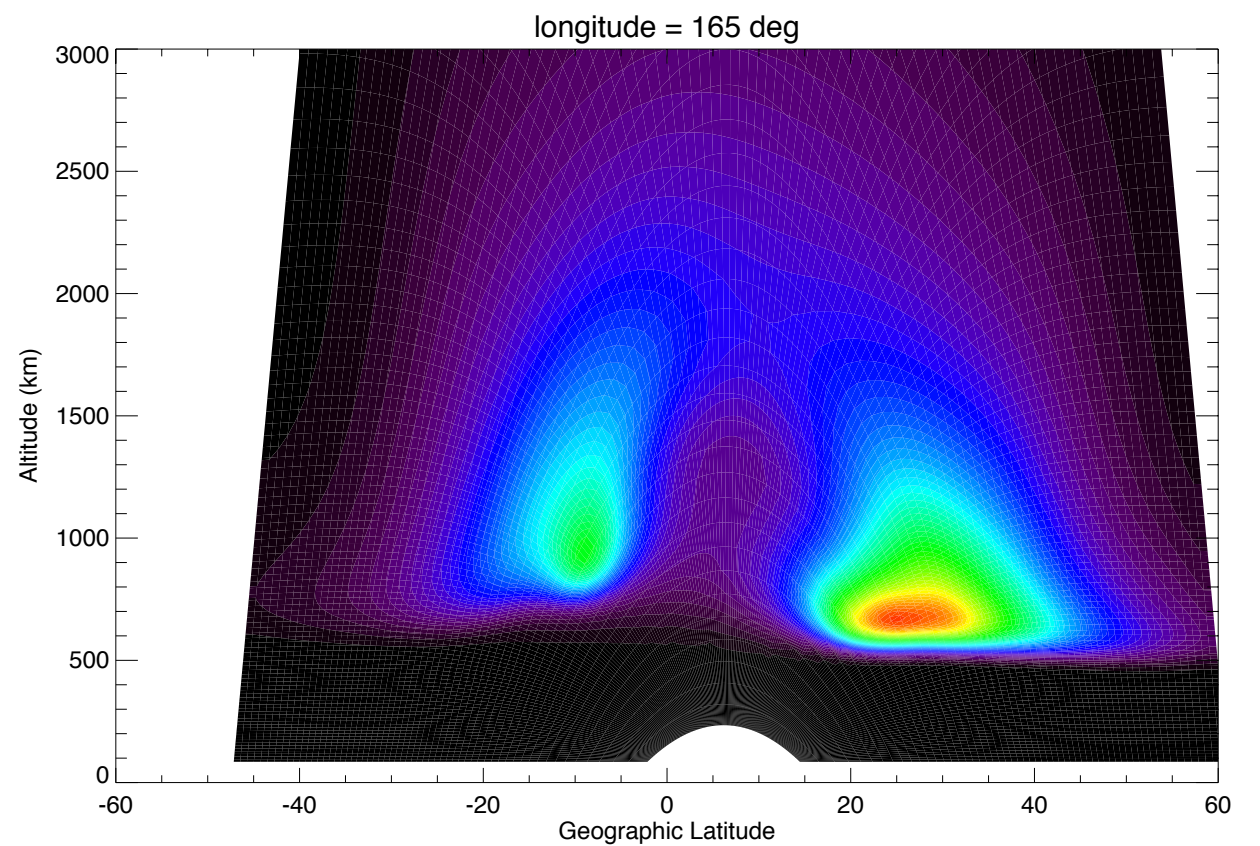
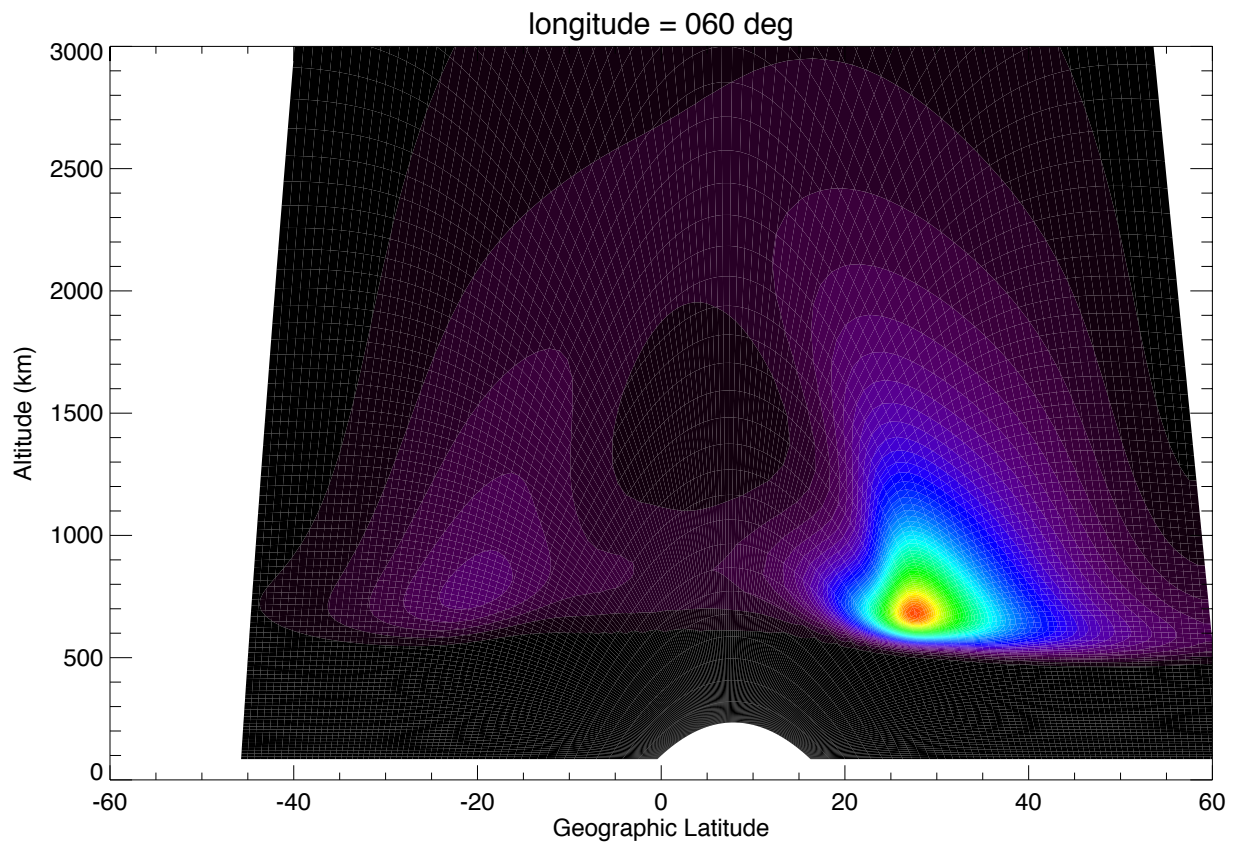


SAMI2 Result Local time Total He ion content 2013-03-21 LT = 18

SAMI2 Result Local time Total He ion content 2013-03-29 LT = 18







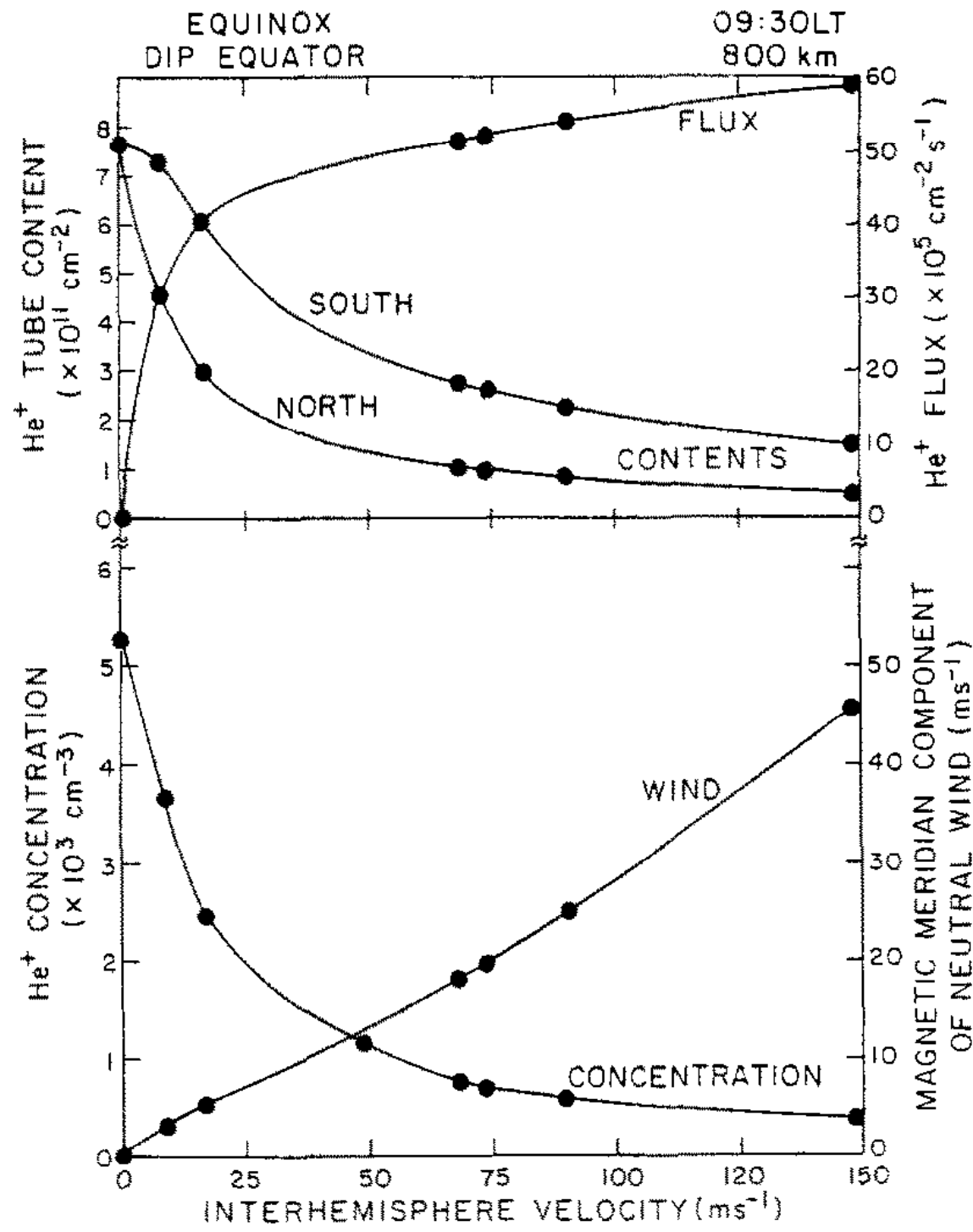
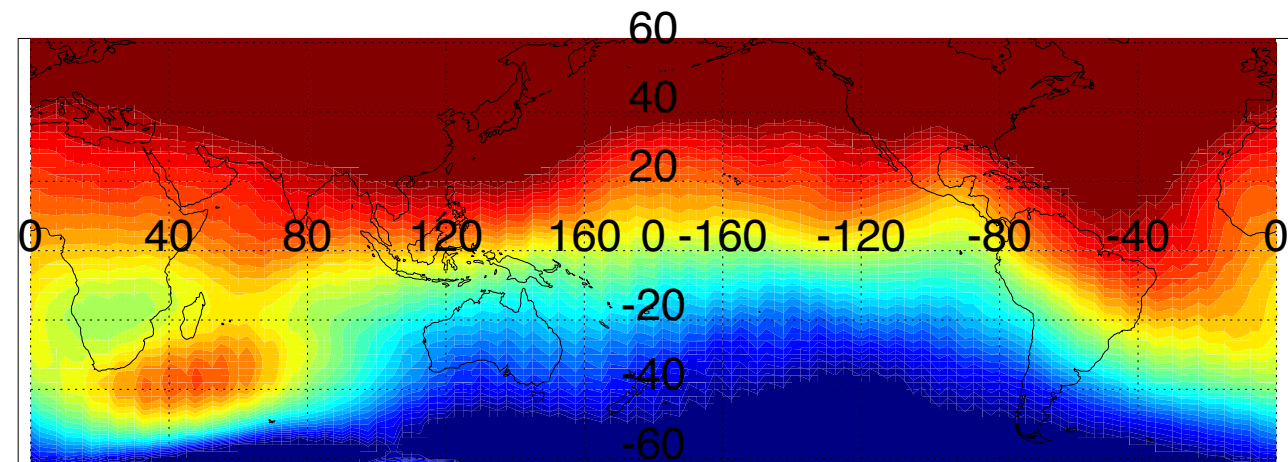
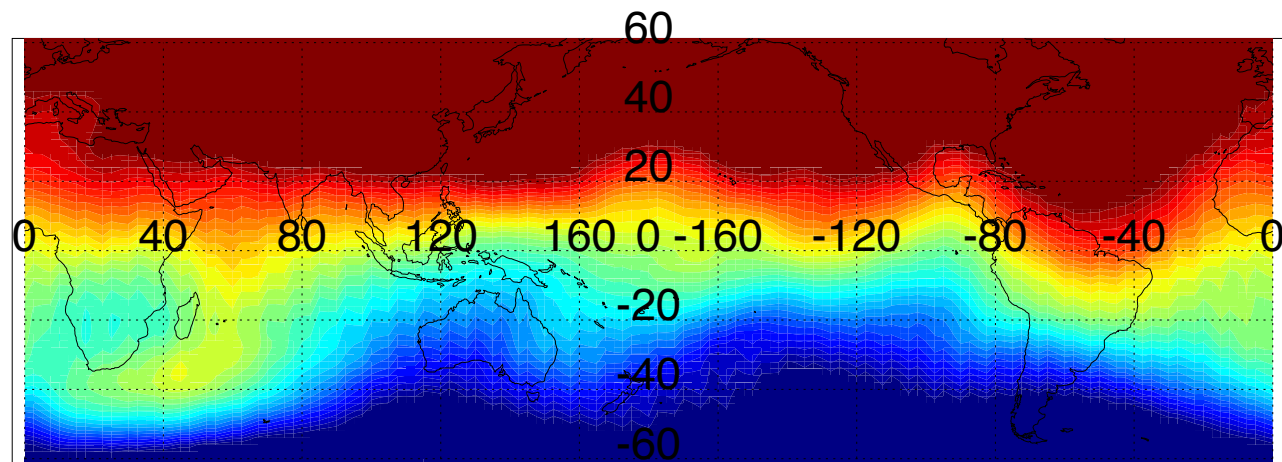


FIG. 4. THE TOP PANEL SHOWS THE He<sup>+</sup> TRANSEQUATORIAL FLUX AND THE MAGNETIC FLUX TUBE CONTENTS OF He<sup>+</sup> AS A FUNCTION OF INTERHEMISPHERIC TRANSPORT VELOCITY. THE LOWER PANEL SHOWS THE VARIATIONS OF THE He<sup>+</sup> CONCENTRATION AT THE TIP EQUATOR AND THE MAGNETIC MERIDIAN COMPONENT OF THE NEUTRAL WIND.

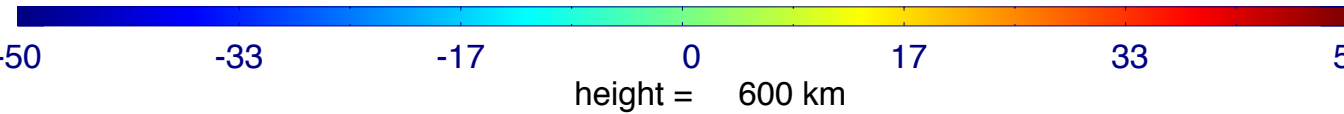
[Murphy et al. 1984]

height = 200 km

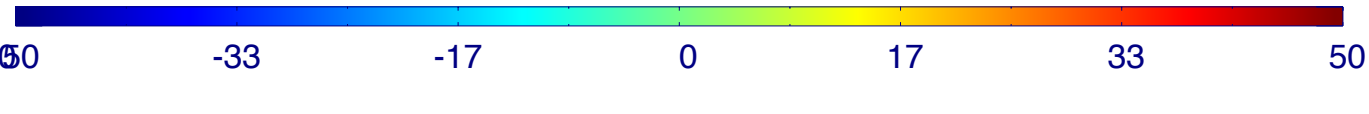
height = 400 km



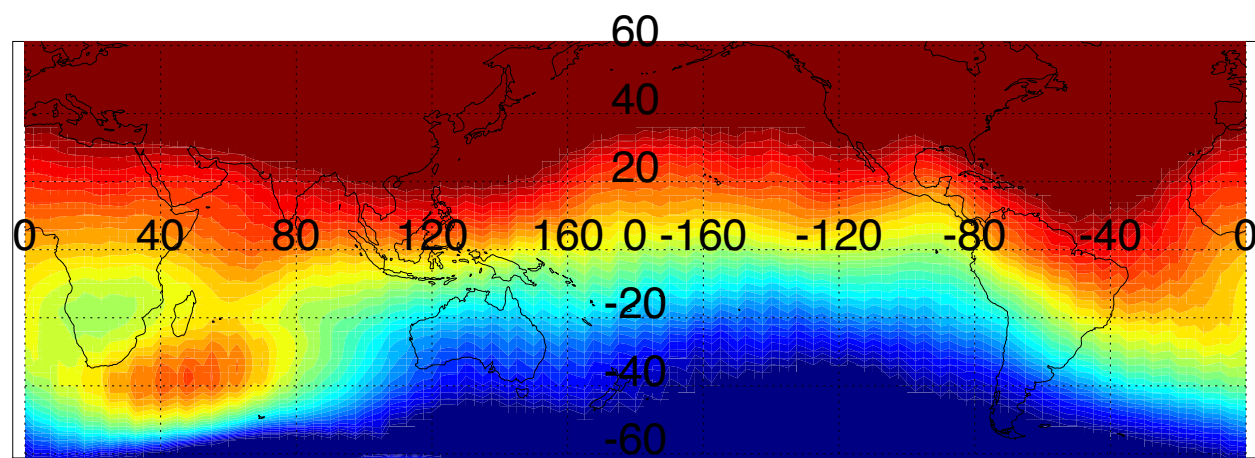
Northward neutral wind velocity [m/sec]



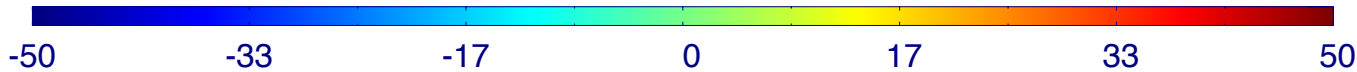
Northward neutral wind velocity [m/sec]



height = 600 km



Northward neutral wind velocity [m/sec]



GAIAの磁力線方向  
の水平風

IGRF

2013.03.01-2013.03.07

LT=6-18の平均

# まとめ

- 共鳴散乱光から上部電離圏のHeイオンの分布を推定した。
- 冬半球でのHeイオンの増大が全Heイオン量でも確認された。
- 春、秋について経度構造がある。
- SAMI2+GAIAの計算で春、秋の経度構造はある程度再現される。

# 今後

- 南北風の経度構造が、Heイオンの経度構造に対してeffectiveなのか確認する。
- 風の影響がeffectiveだとして、南北風の経度構造の潮汐、磁場の寄与を議論する。