

SuperDARN北海道-陸別HFレーダーで観測された サブオーロラ帯高速流の発生特性

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SAPS

SAPS (Sub-Auroral Polarization Stream)^[1] Foster, J. C., and H. B. Vo., 2002.

サブオーロラ帯に生じる西向きプラズマ流

SAPS中の狭い範囲の速度の速い部分

- SAID(Sub-Auroral Ion Drift)^[2] Spiro *et al.*, 1979.
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先行研究

- 発生するMLTによって発生緯度、速度の分布が変わる^[1]
- IMFの南向き成分が強くなると速度が速くなる^[4] Oksavik *et al.*, 2005
- Dst指数が強くなると発生緯度が低下する^[5] Kataoka *et al.*, 2009.

地磁気擾乱時に低緯度までSAPSが広がったときのデータが少ない
速度の範囲や発生条件に関して未解明の部分がある

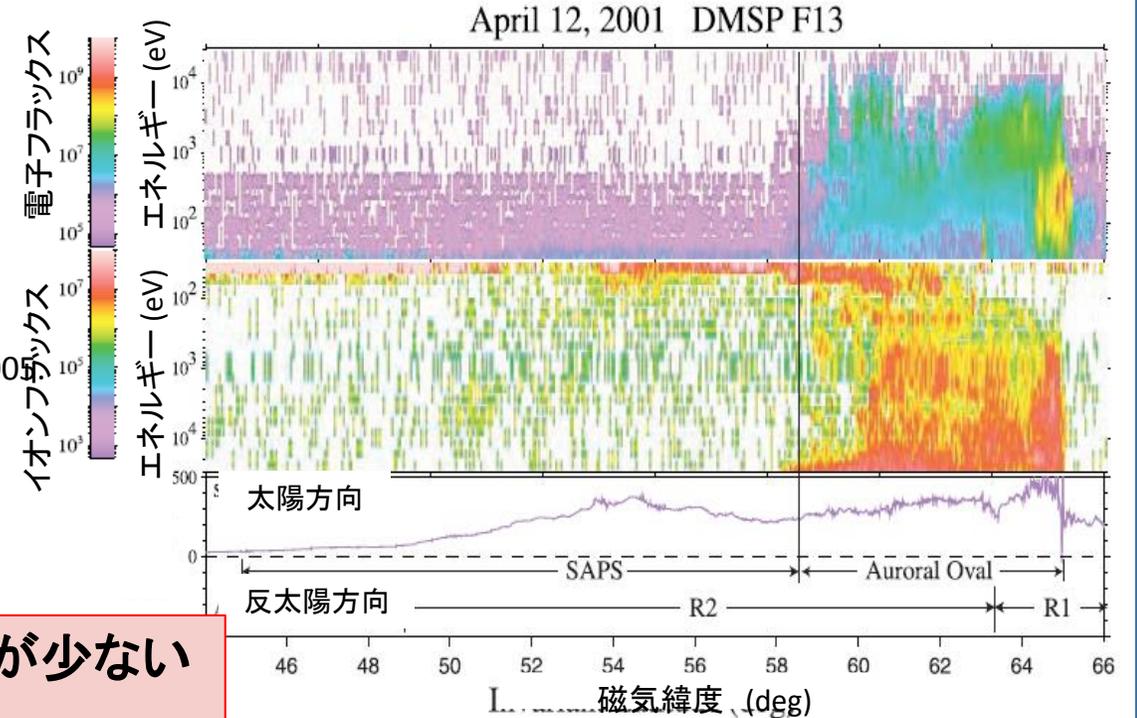
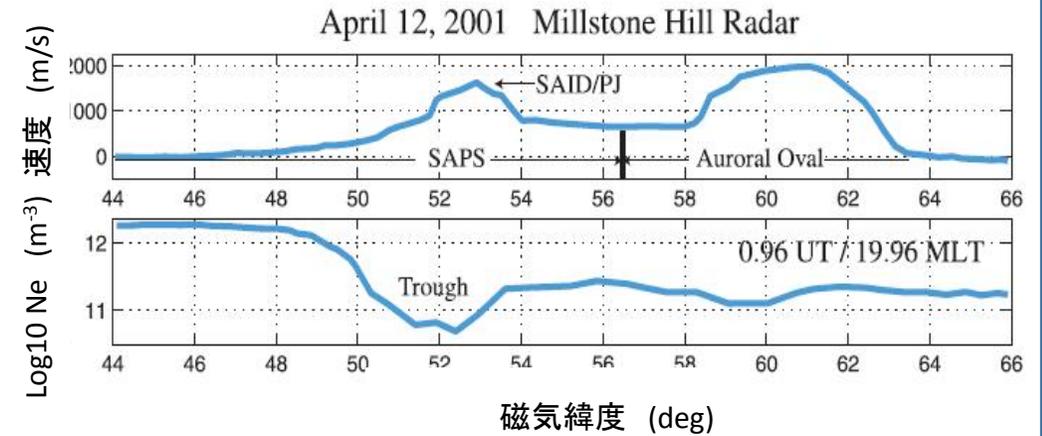


図1^[1] 上:SAPSと電子密度の増減
下:SAPSと電子の振り込み、水平ドリフト方向

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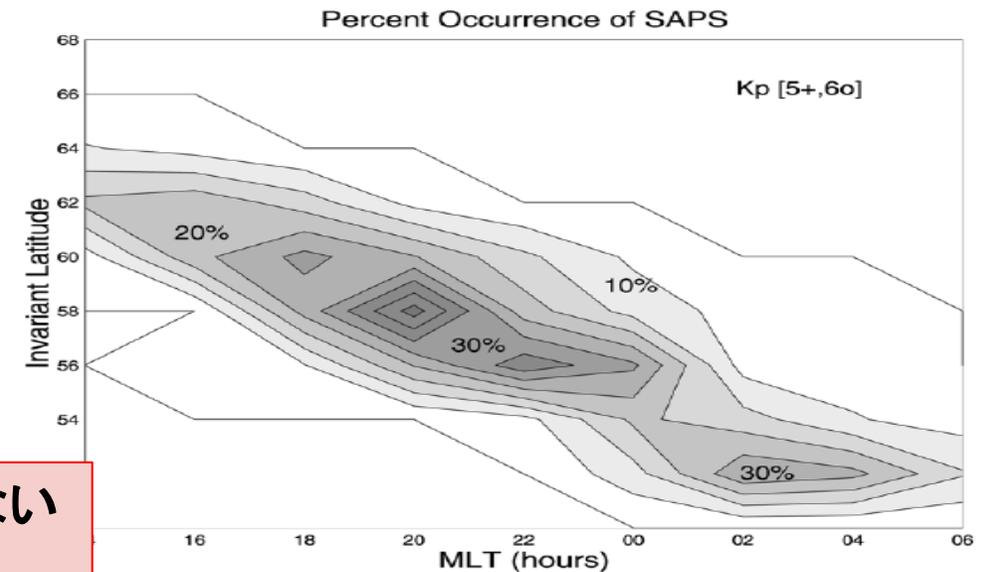
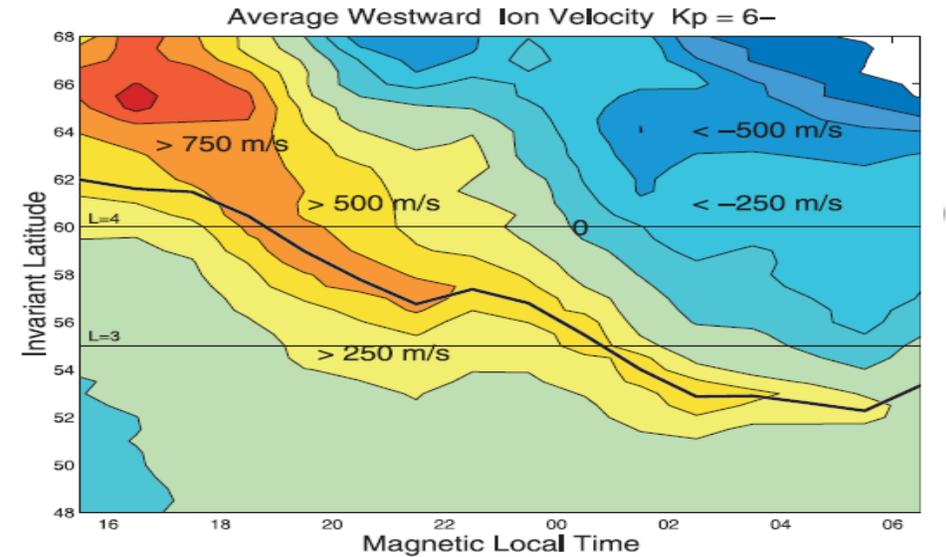


図2^[1] SAPS発生緯度、速度とMLTの関係

SAPS



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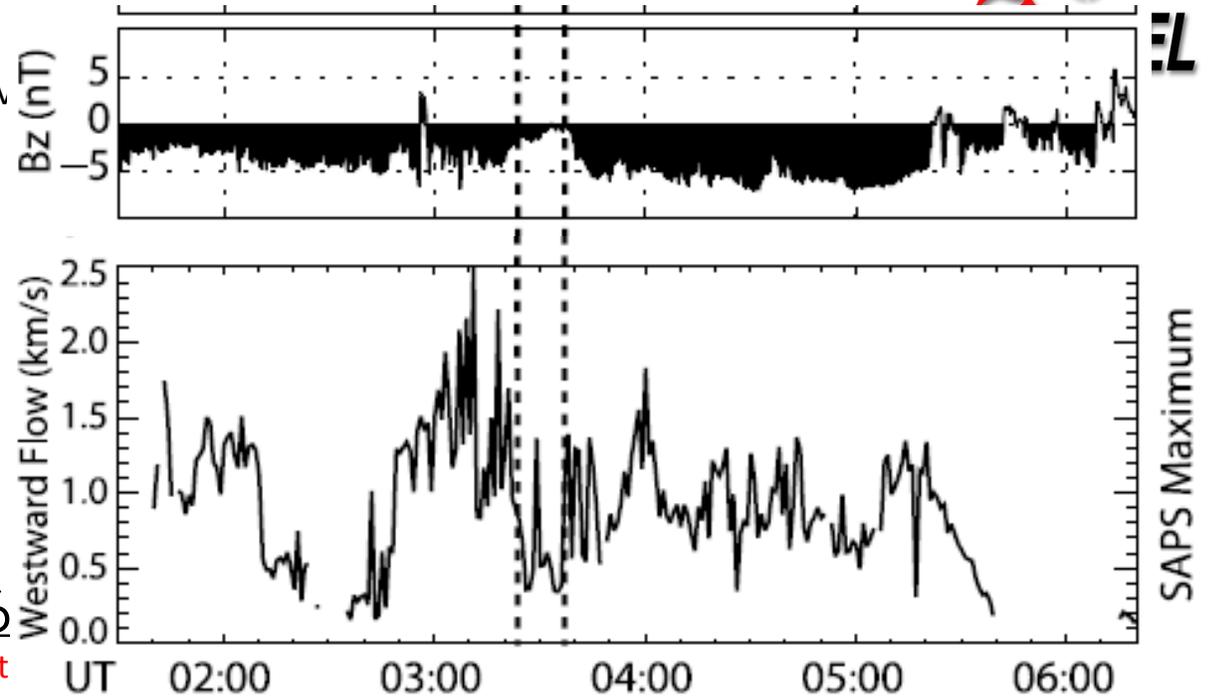


図3^[4] SAPS速度とIMFz成分の関係

SAPS



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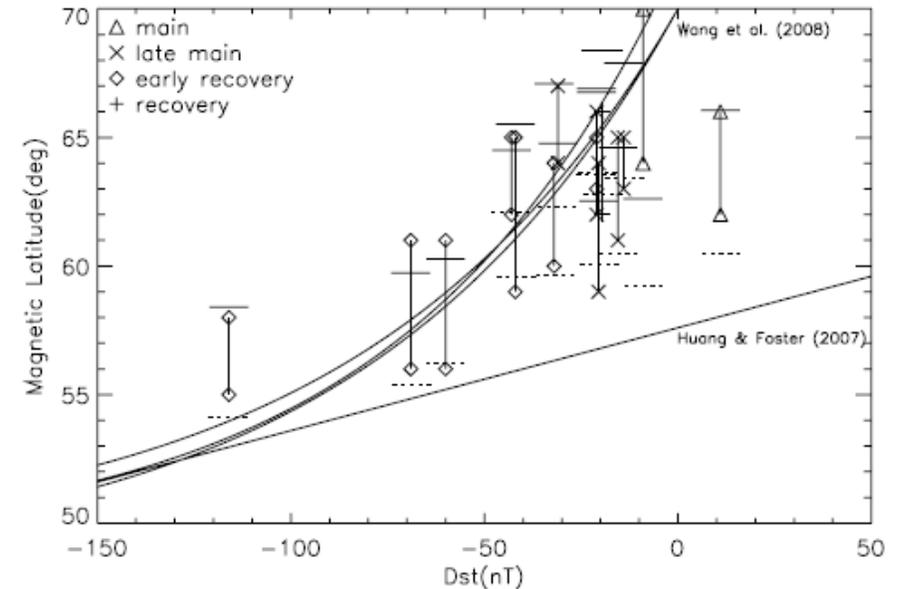


図4^[5] Dst指数とSAPS発生緯度

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北海道-陸別HFレーダー

- ・従来のレーダー
→ 中緯度~極域の観測
- ・北海道-陸別HFレーダー
→ 従来のものよりも低緯度側の観測
磁気緯度 36.46° , 磁気経度 -145.34°

電離圏の密度変動によって電波が後方散乱されるブラッグ散乱を観測しドップラー効果からドップラー速度を得る

➡ 電離圏の対流速度を同定

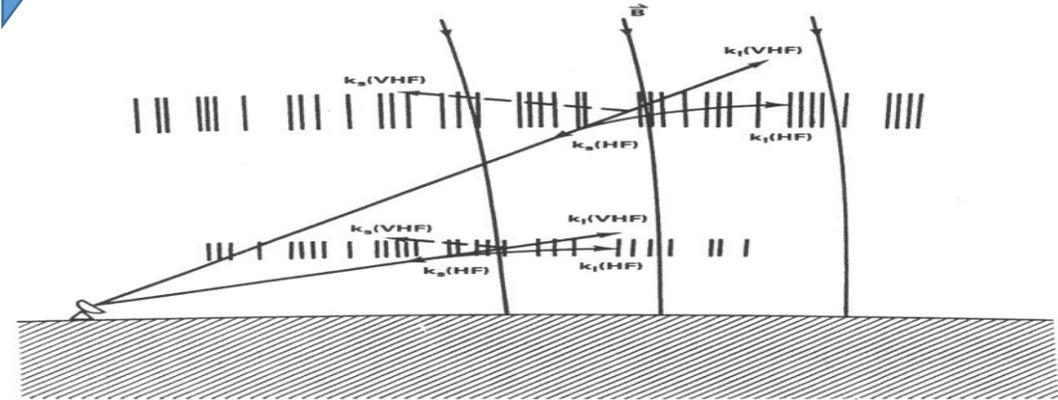


図4 HFレーダーの観測原理

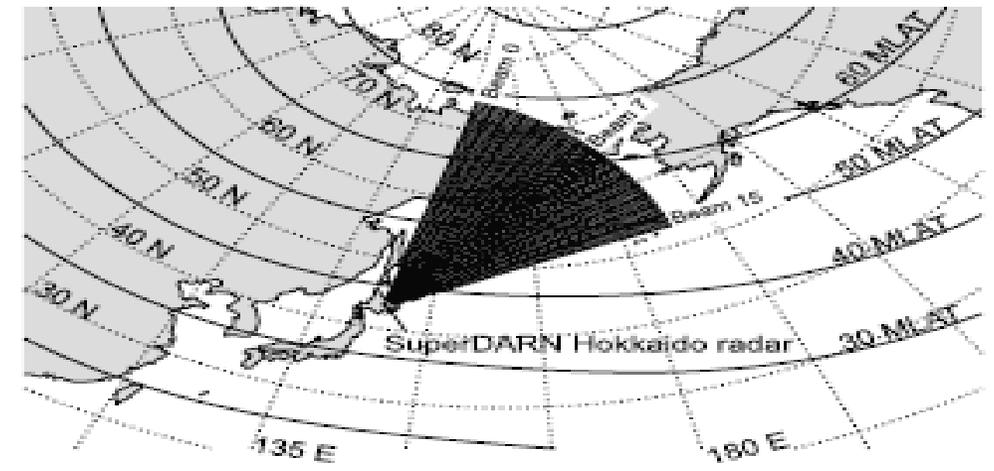
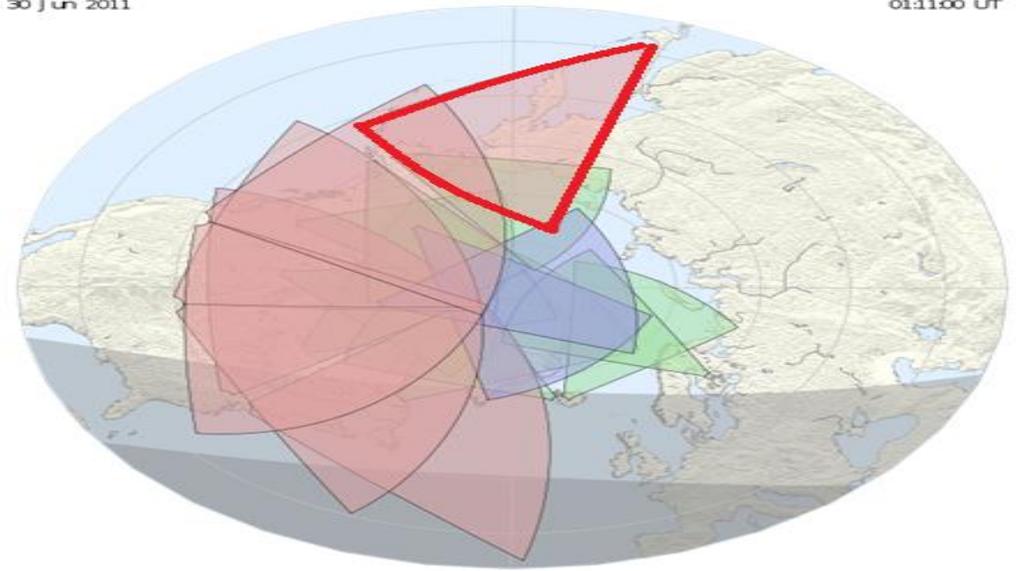


図2,3 北海道陸別HFレーダー照射方向

SAPSの速度による緯度依存性の変化を調査

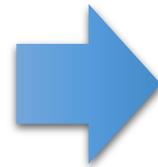
サブオーロラ帯西向きプラズマ対流について61日分のイベントから623点のデータを解析しサブオーロラ帯西向きプラズマ対流の発生緯度を縦軸に、SYM-HとAL指数を横軸にとりいつ、どこで、どういう状況で発生したかをまとめる。

その結果、速度により2種類の異なる性質を持つデータが見いだされたためその閾値を明らかにする。

また、より広義のプラズマ対流について調べるため期間、速度範囲、緯度を先行研究より広くとる。

Kataoka et al. (Ann. Geophys., 2009)

北海道陸別-HFレーダーで観測した
期間2006/12~2008/4 速度 >1.0km/s
磁気緯度 45~65° イベント数 15日



今回の調査

期間2006/12~2013/9 速度 >10.0m/s
磁気緯度 40~70° イベント数 61日

方法(2013-3-17の例)

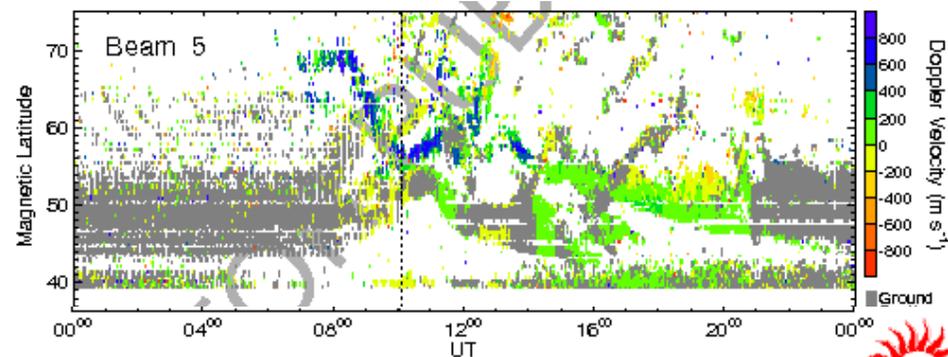
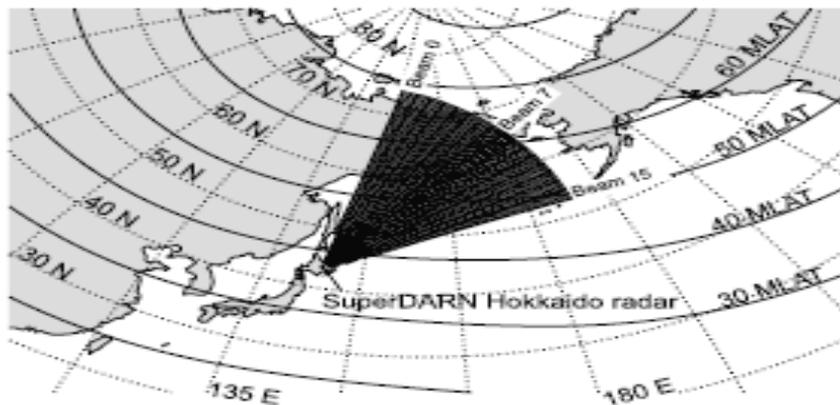
SAPSと思われるイベントを同定



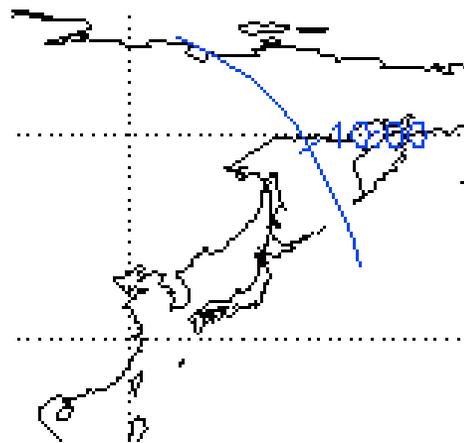
付近を周回しているNOAA衛星によって得た
TEDから電子の振込の確認しサブオーロラ帯の区別



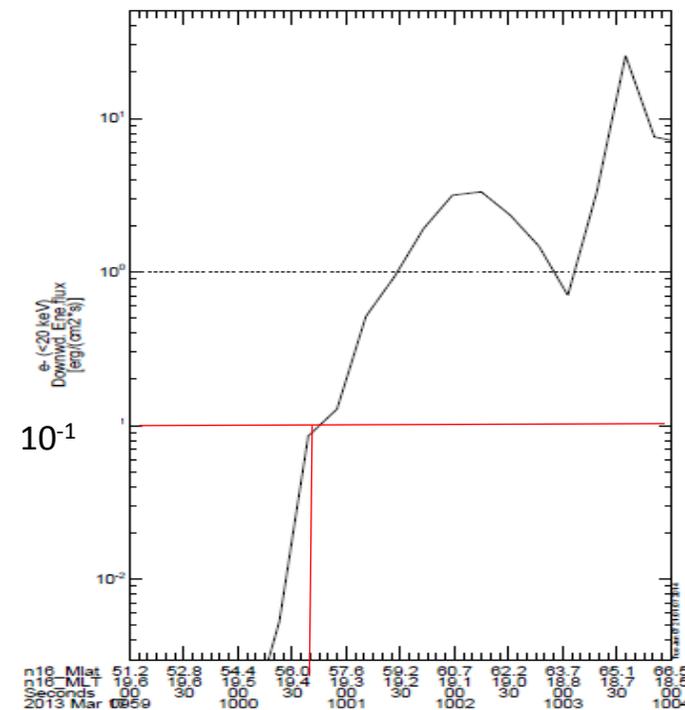
30分毎に西向きフローの速度、緯度、SYM-H
AL指数を取得



Quick Look plot created by rtslari,
00:11 UT 18 Mar 2013



NOAA16の軌道
(9:55:00~10:05:00)



NOAA16が取得したTED

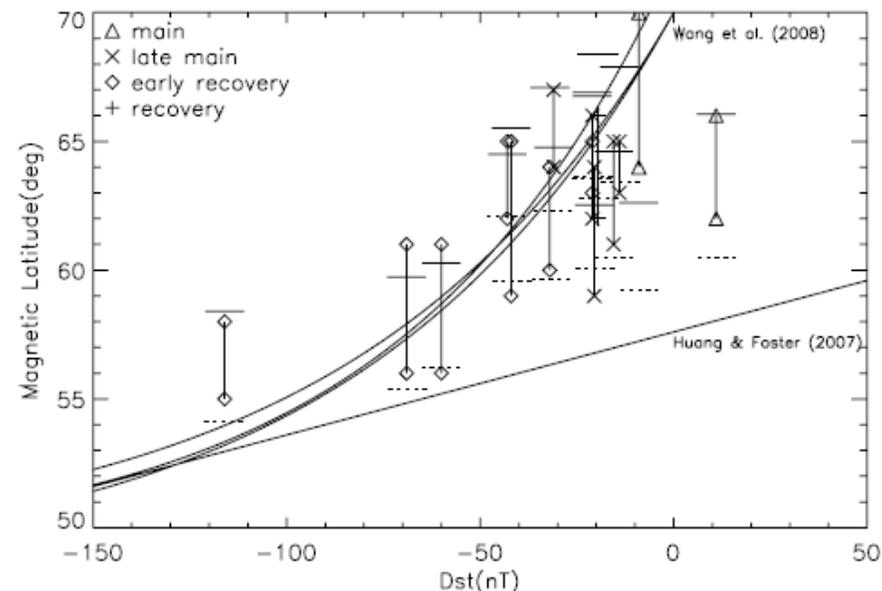
Wang et al., 2008.

DstとSAPSの緯度の関係式を
伝導度別に3つの式で表す

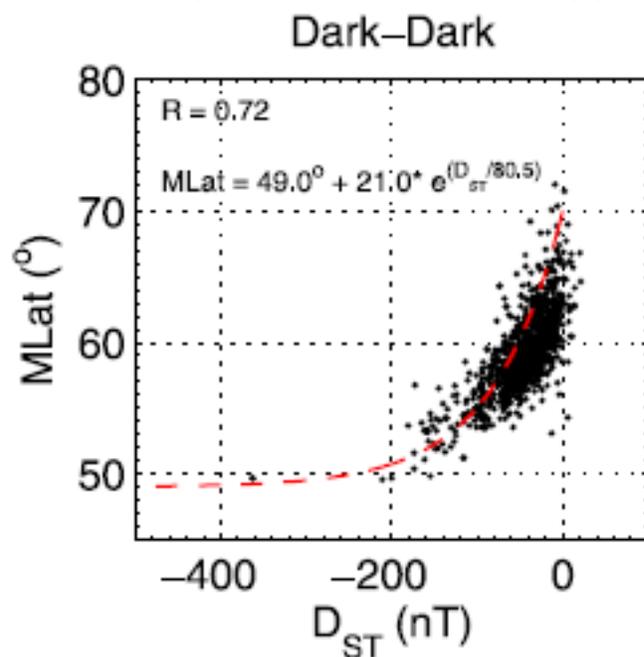
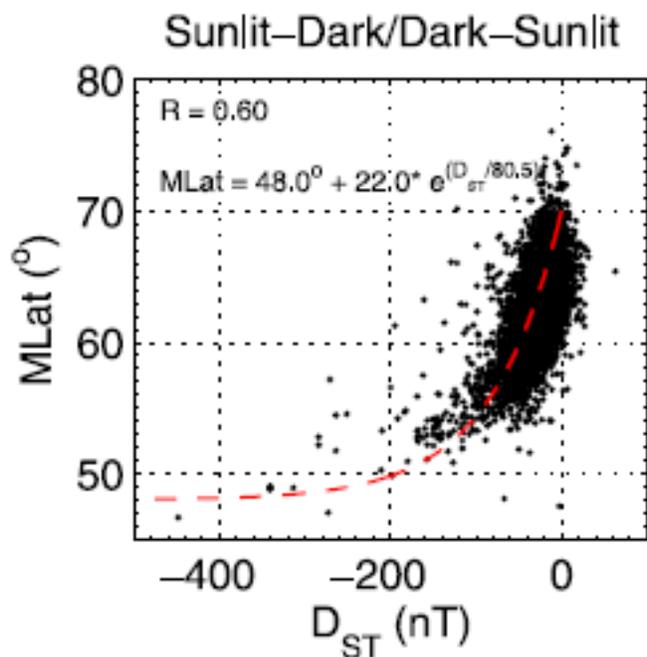
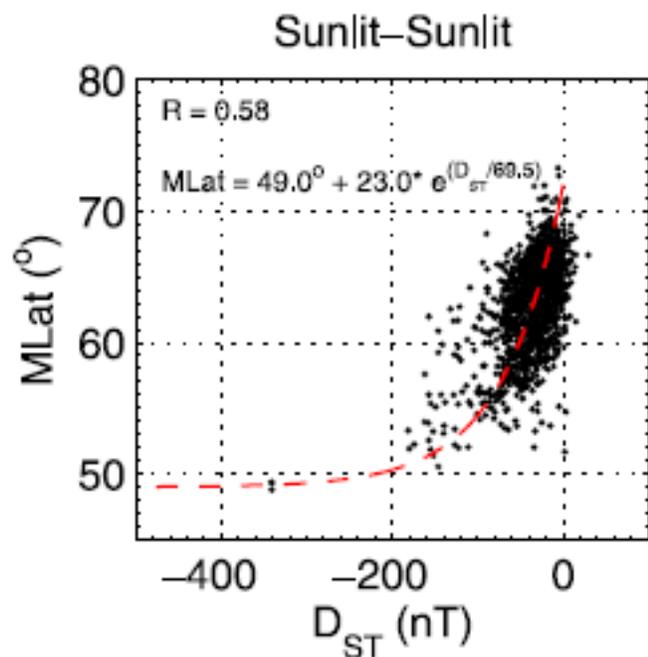
$$MLAT = 49^\circ + 23e^{Dst/69.5}$$

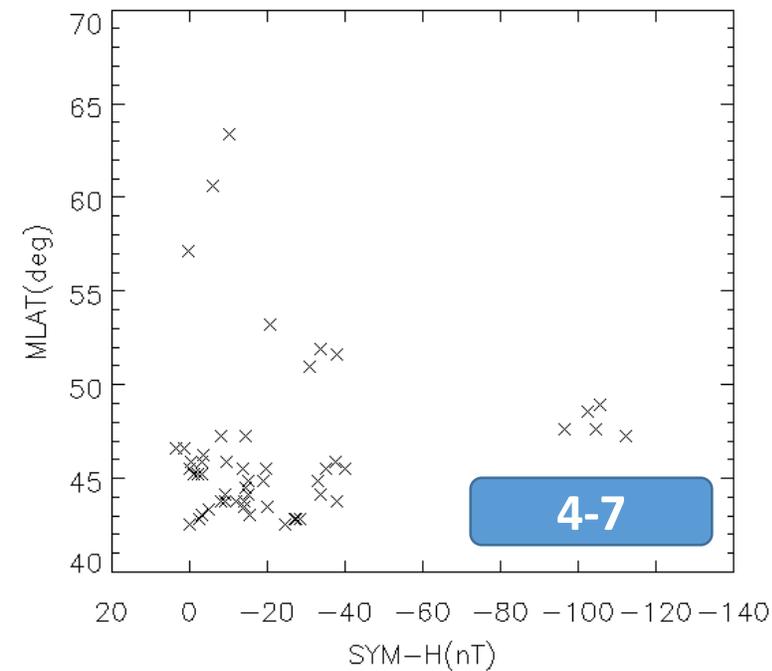
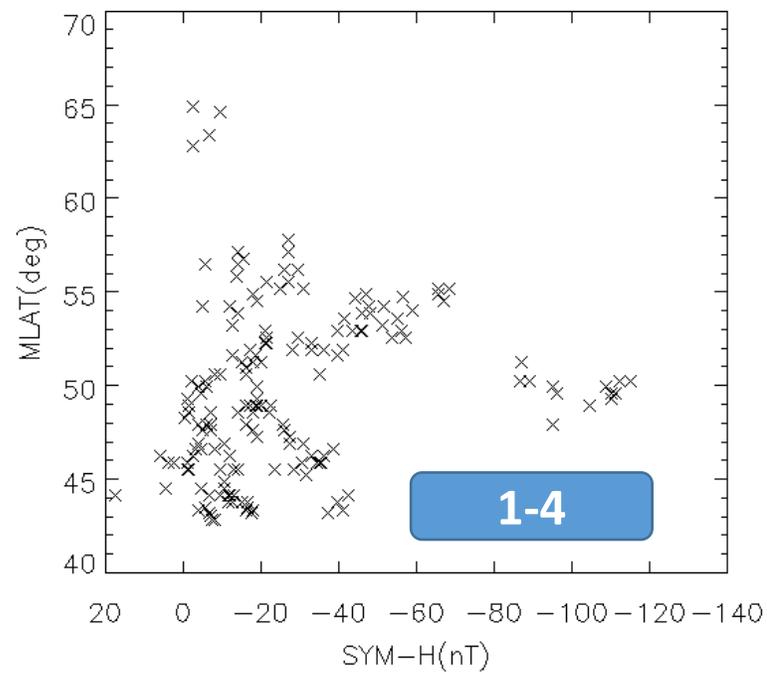
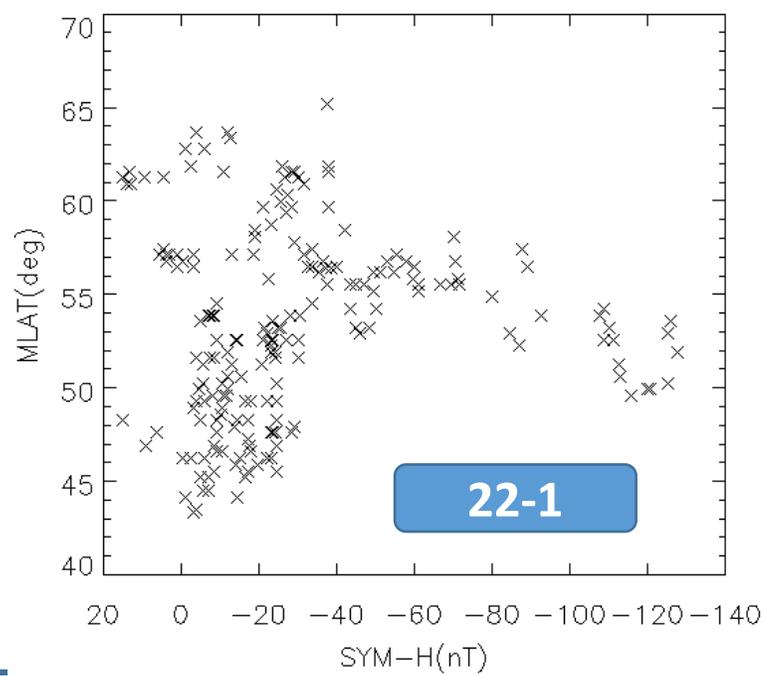
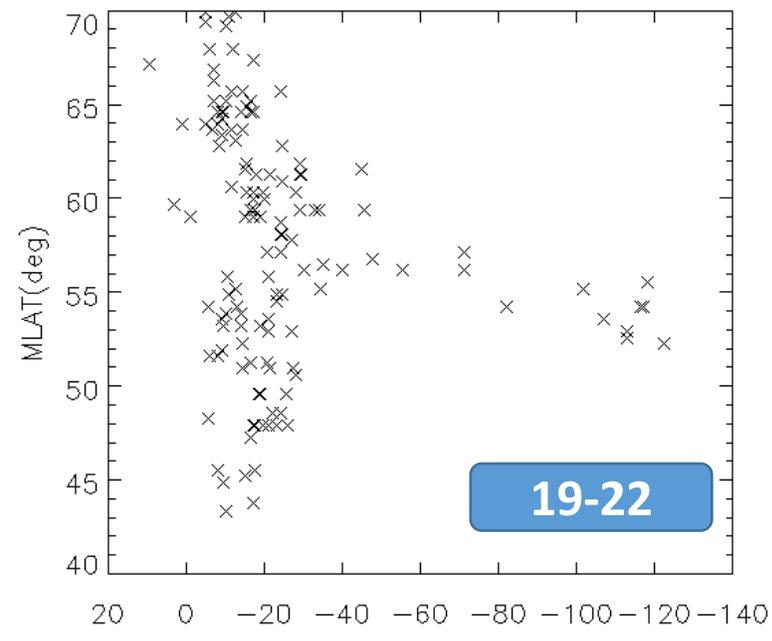
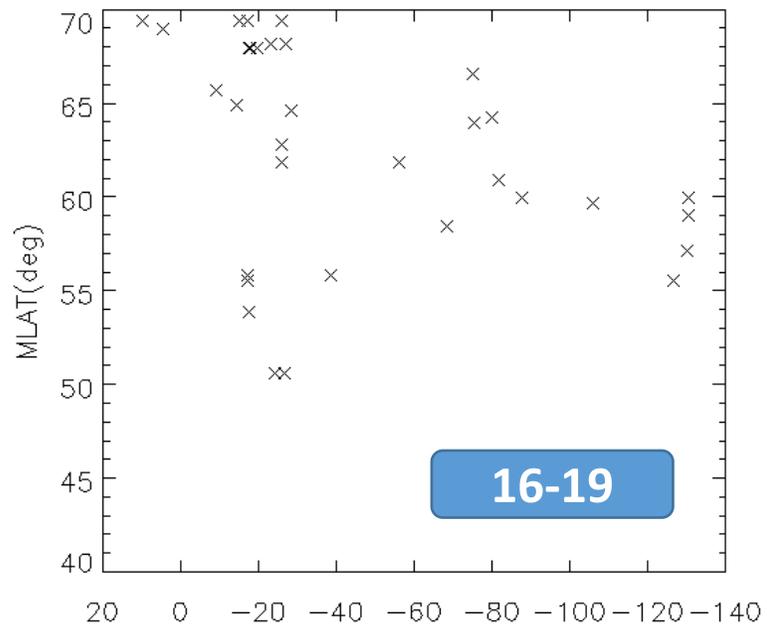
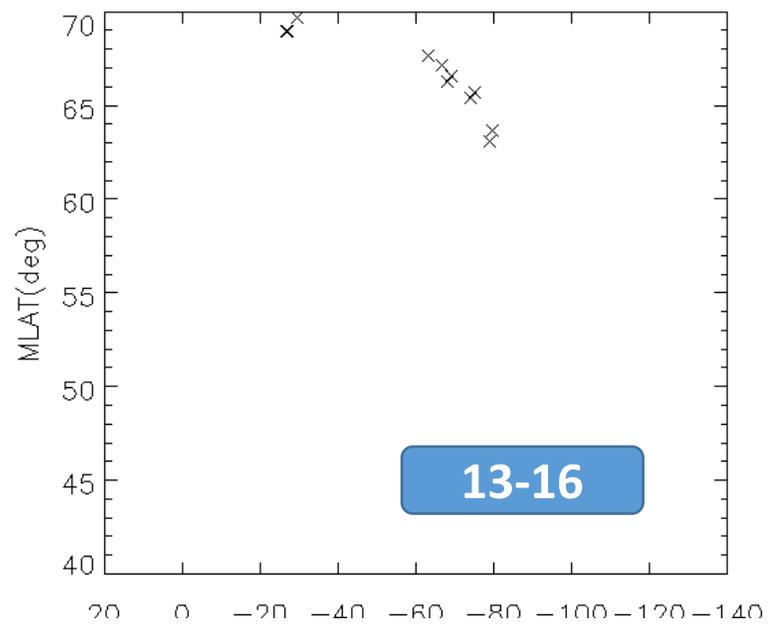
$$MLAT = 48^\circ + 22e^{Dst/80.5}$$

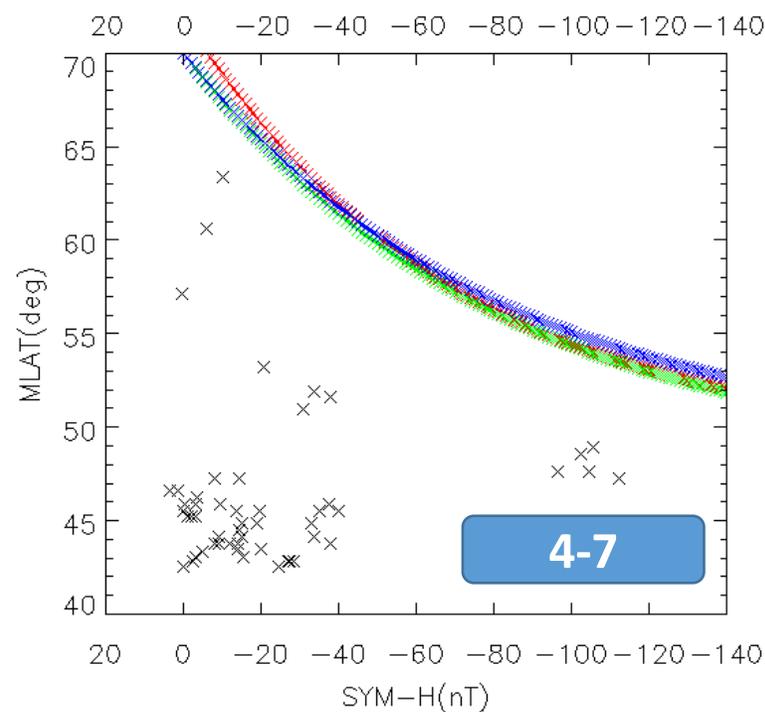
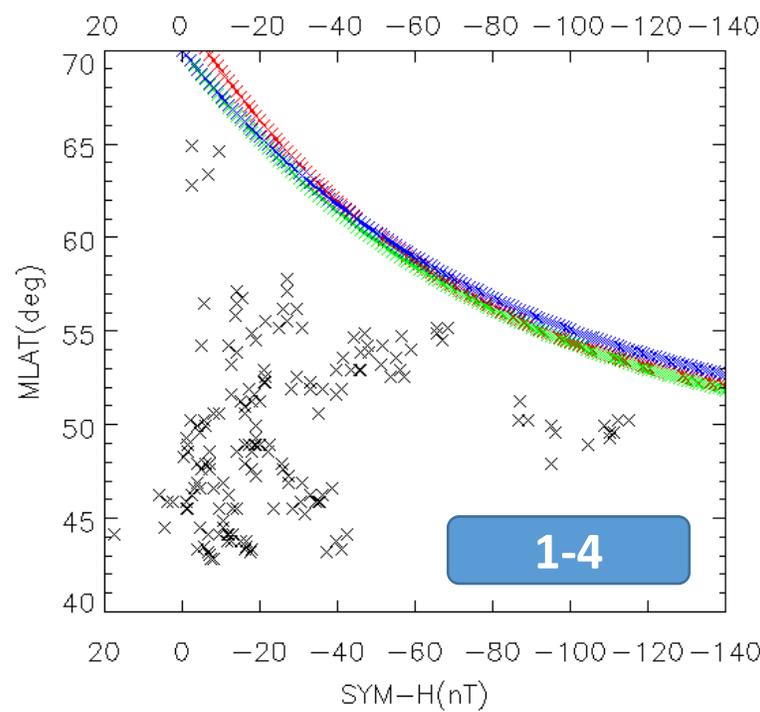
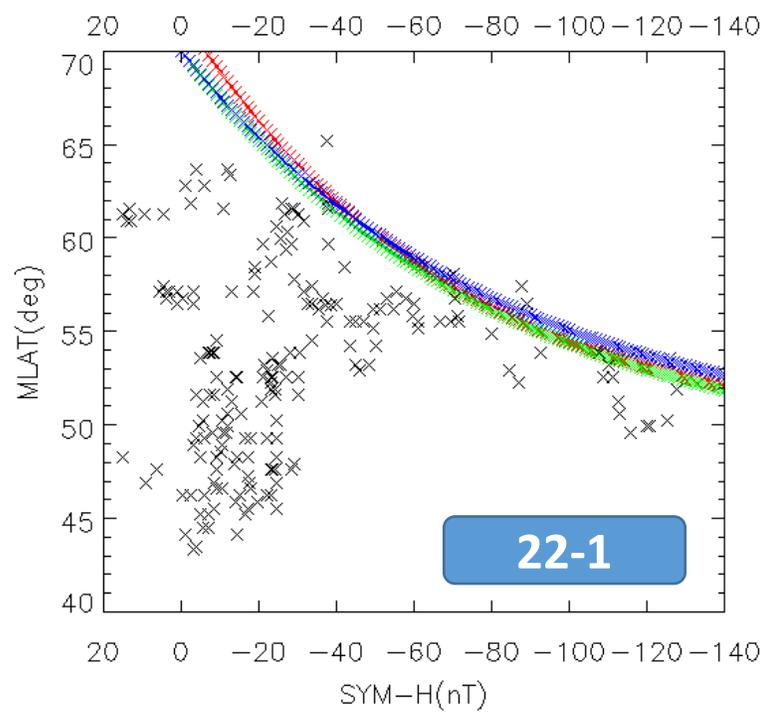
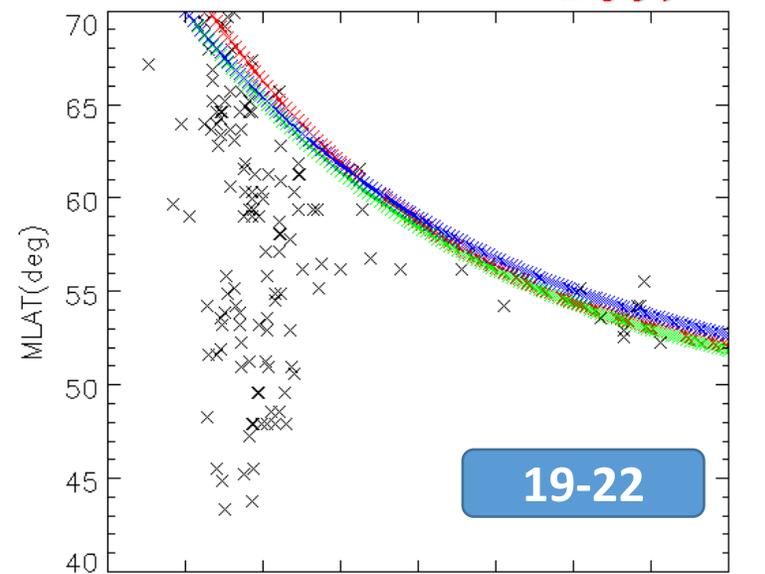
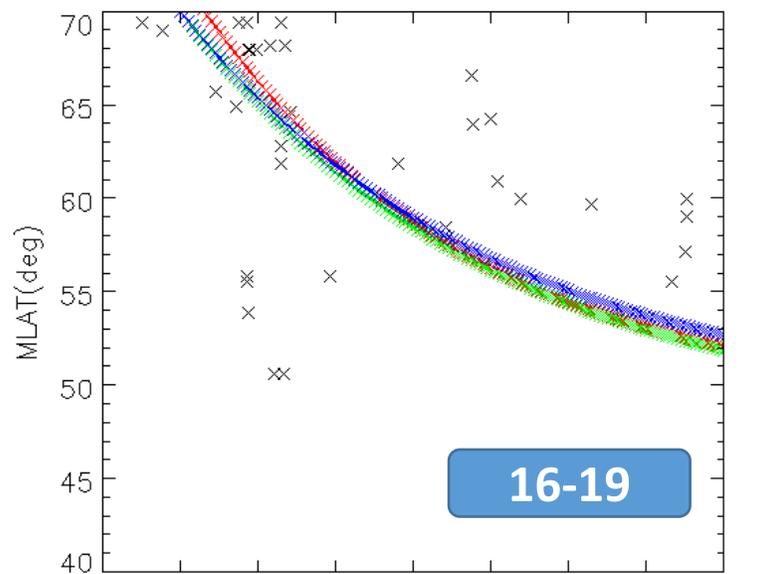
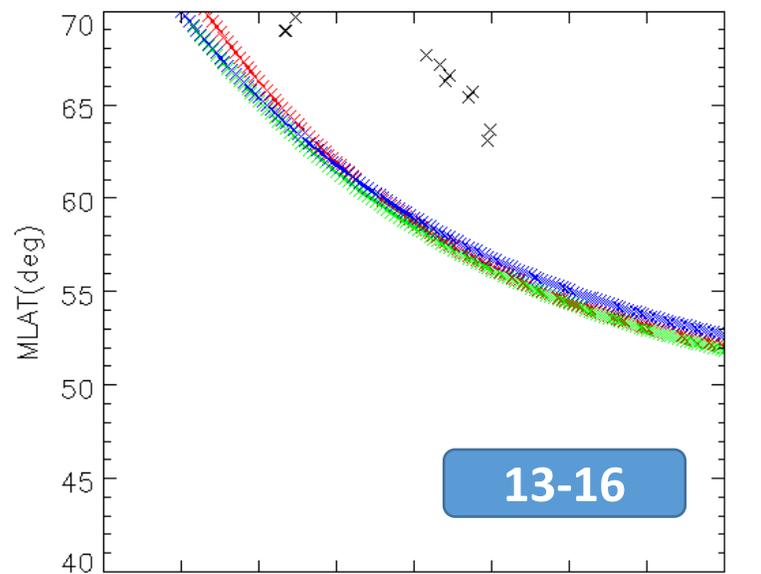
$$MLAT = 49^\circ + 21e^{Dst/80.5}$$

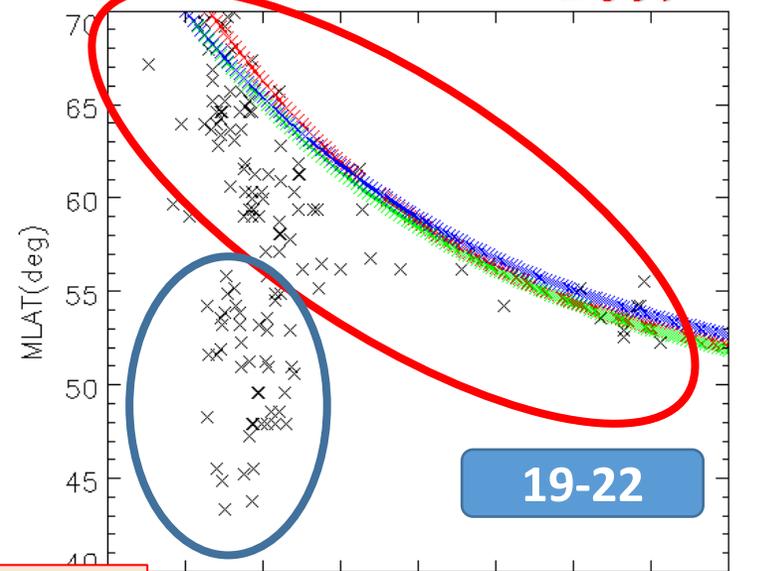
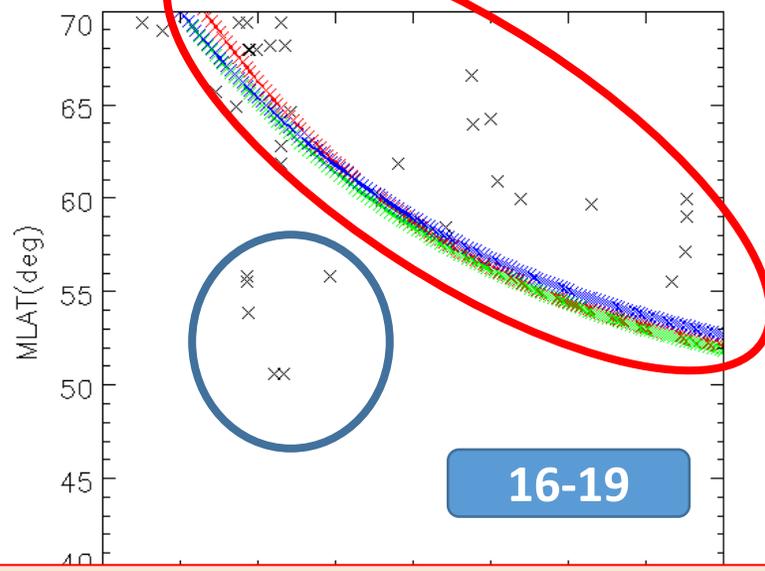
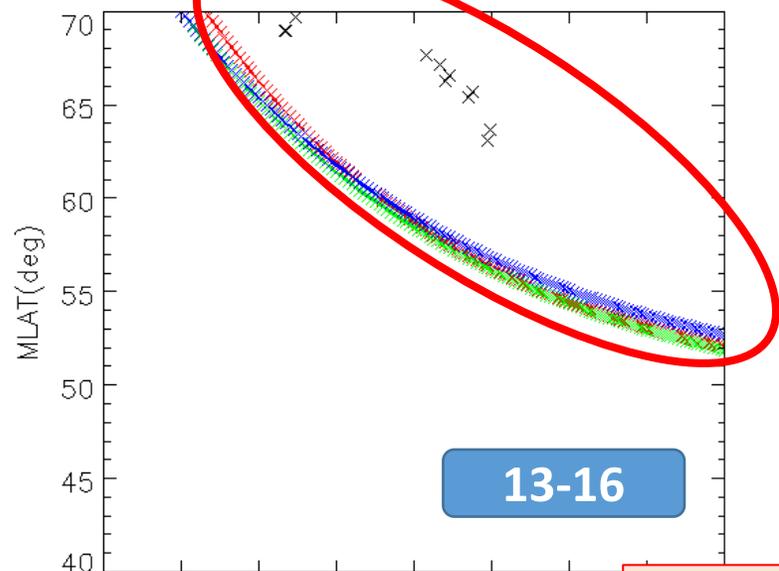


発生したSAPSの緯度とWangの式^[5]

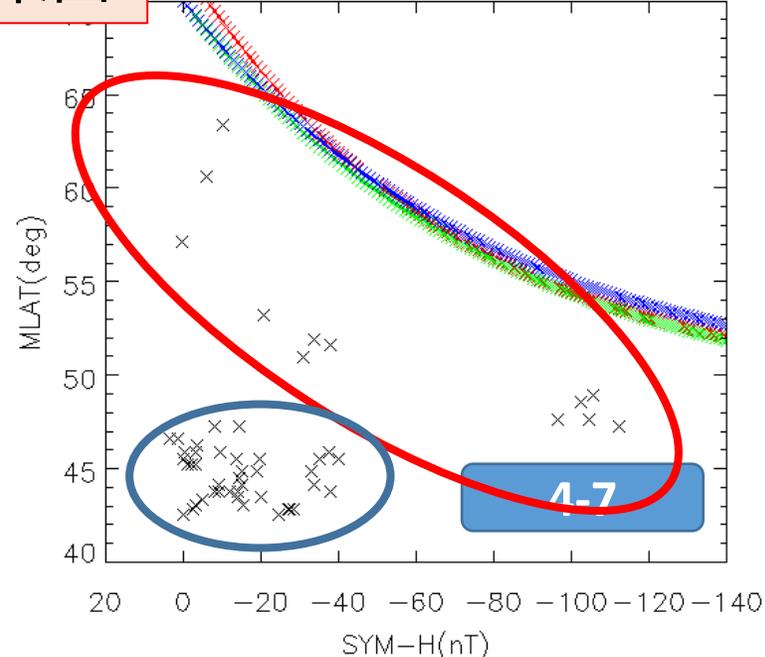
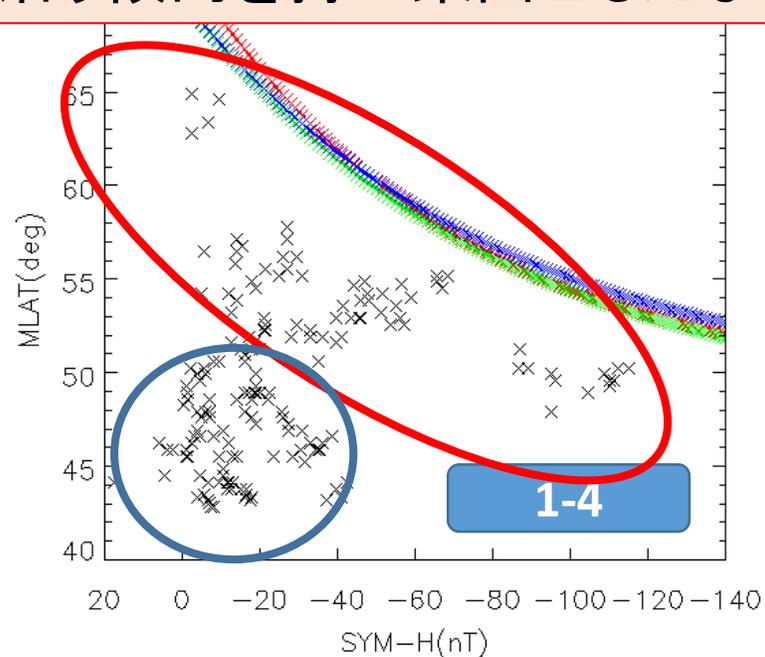
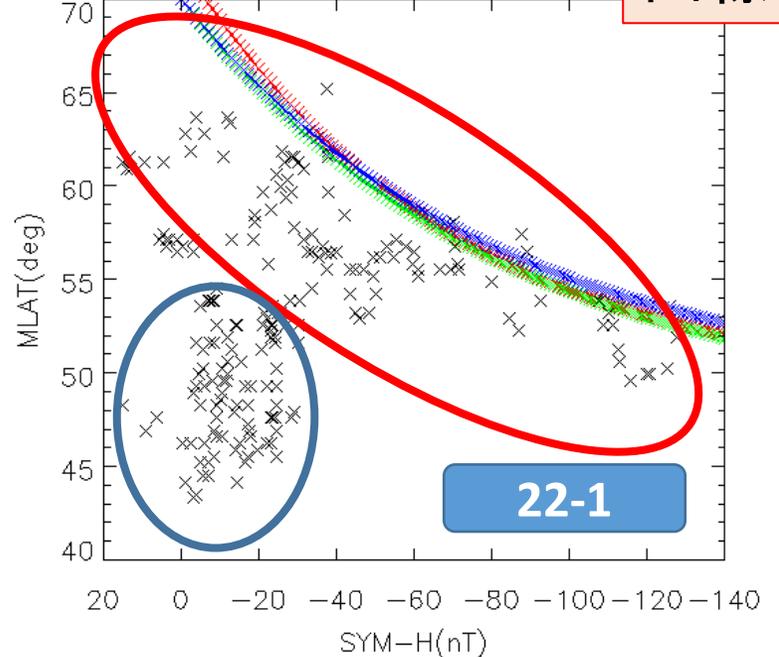




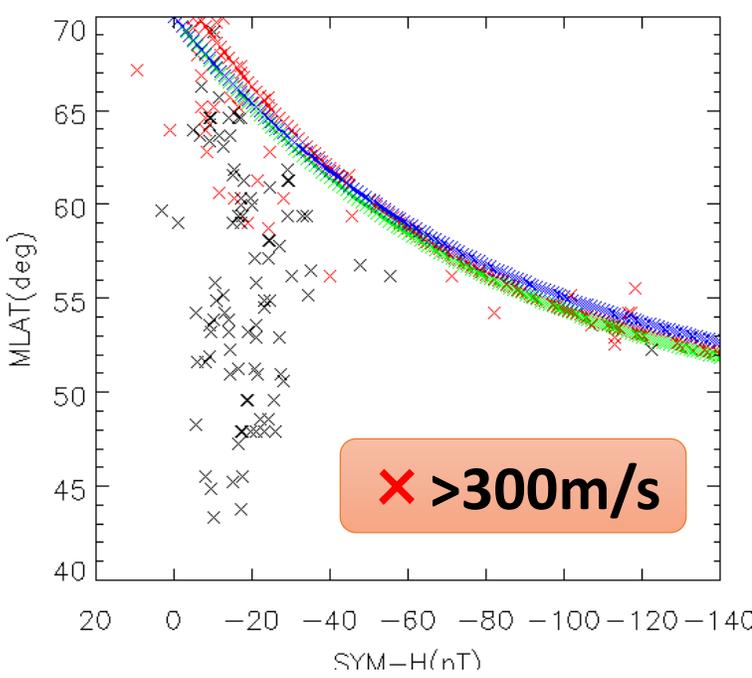
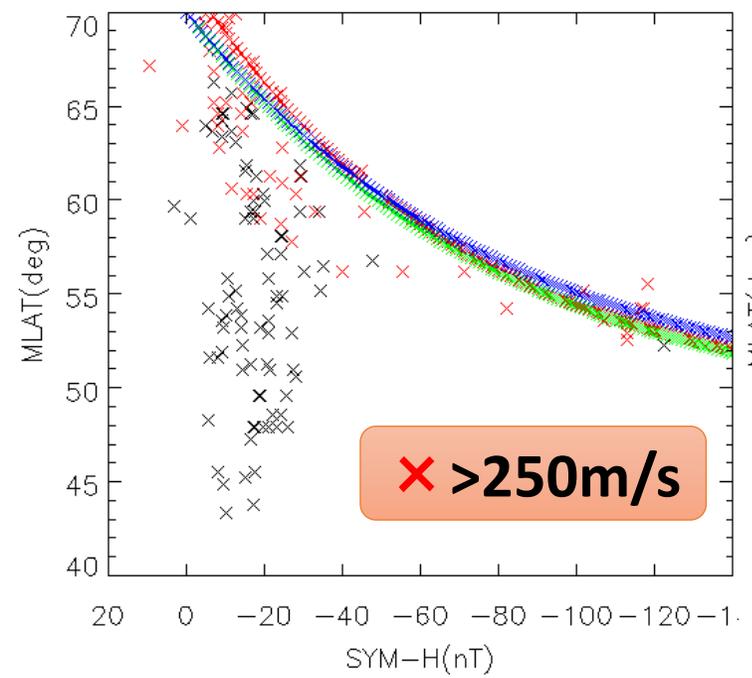
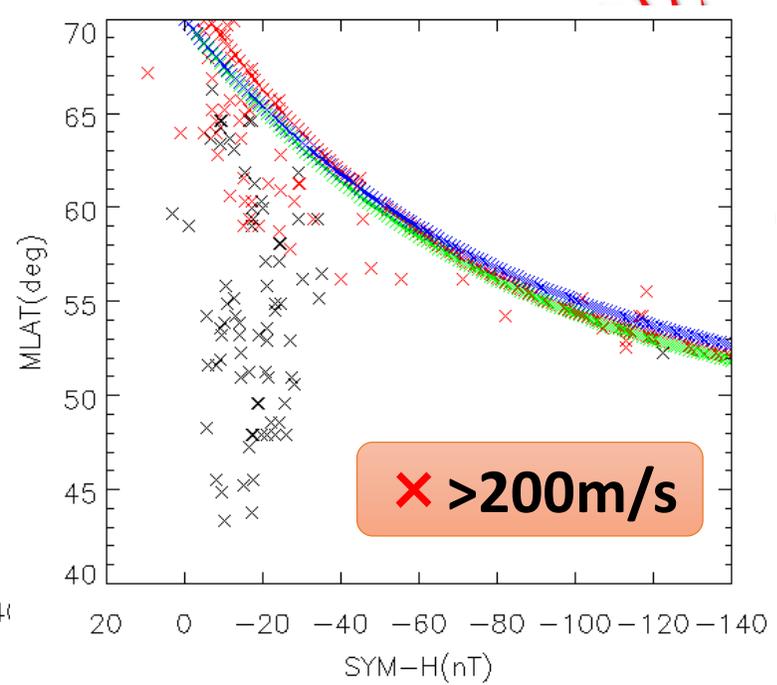
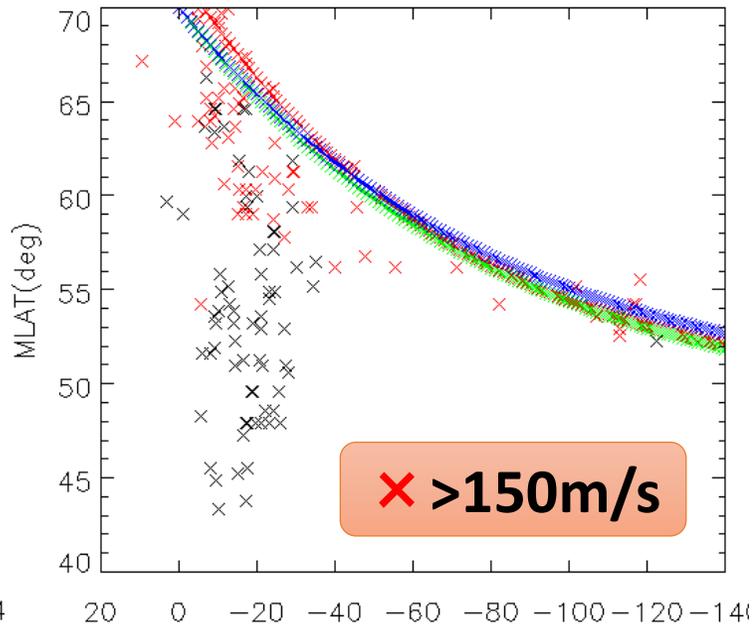
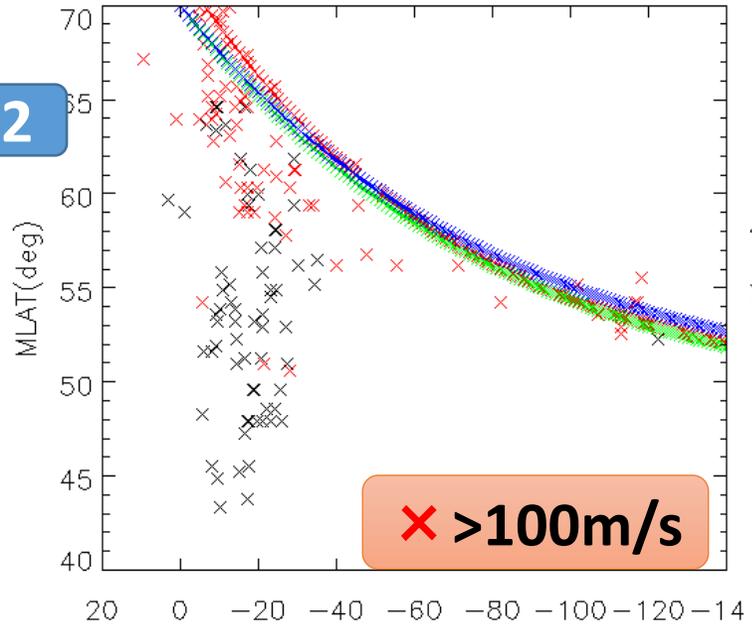




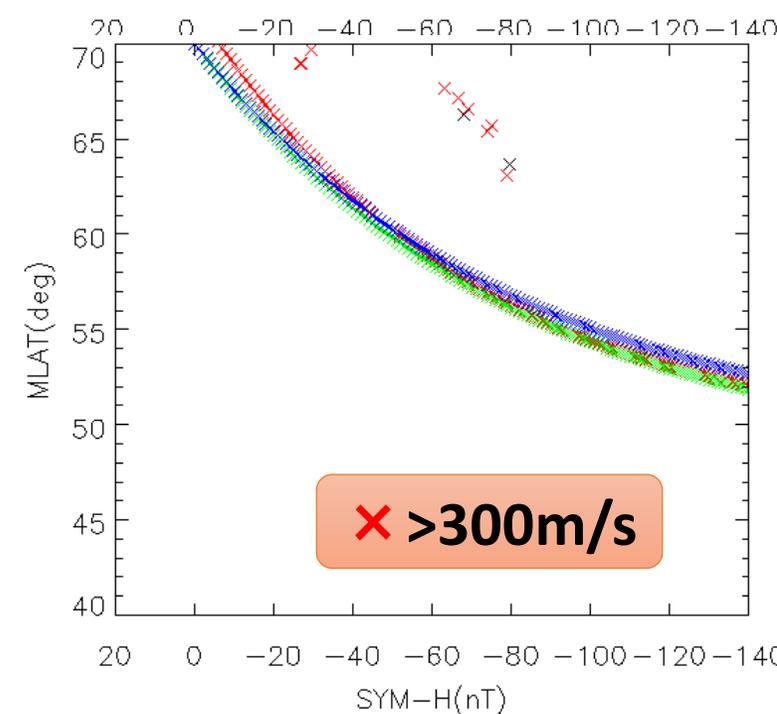
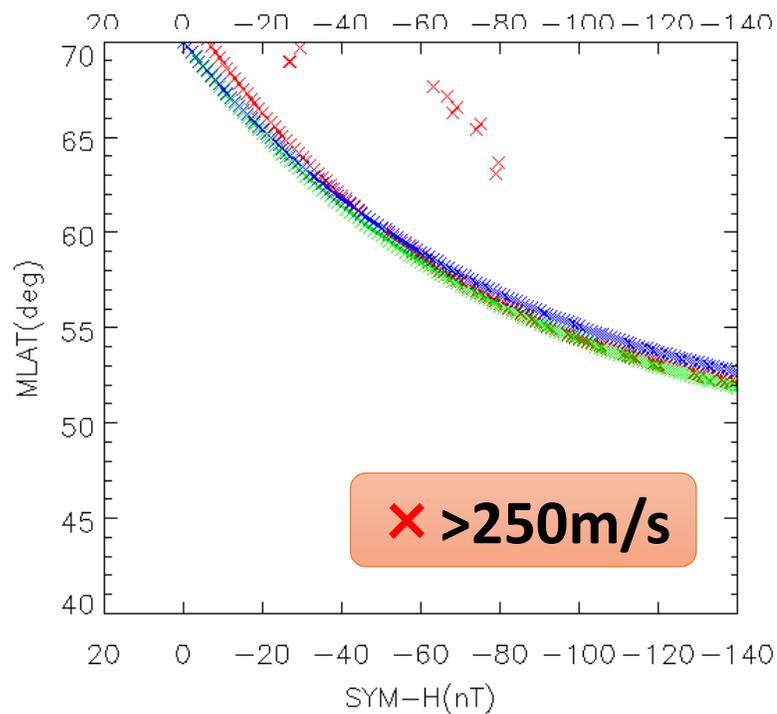
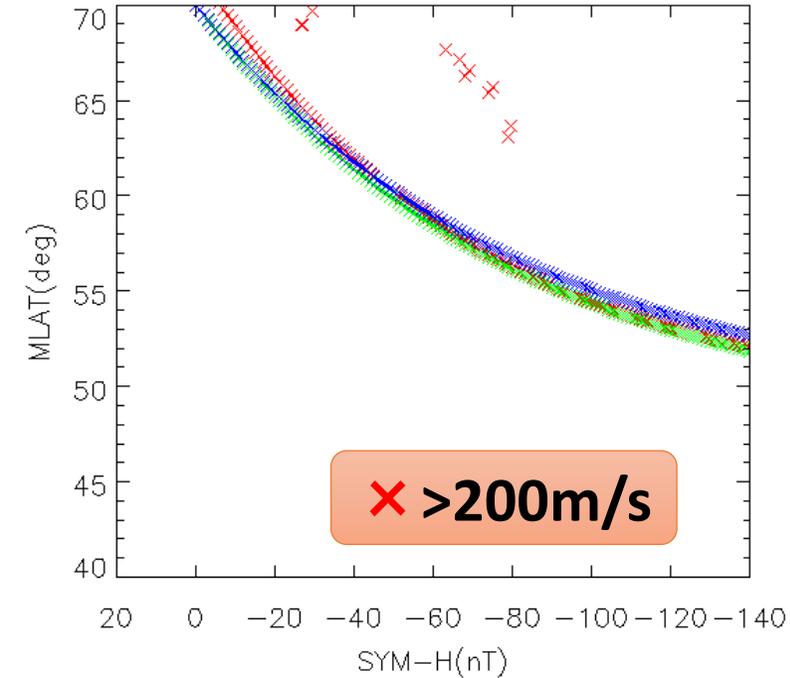
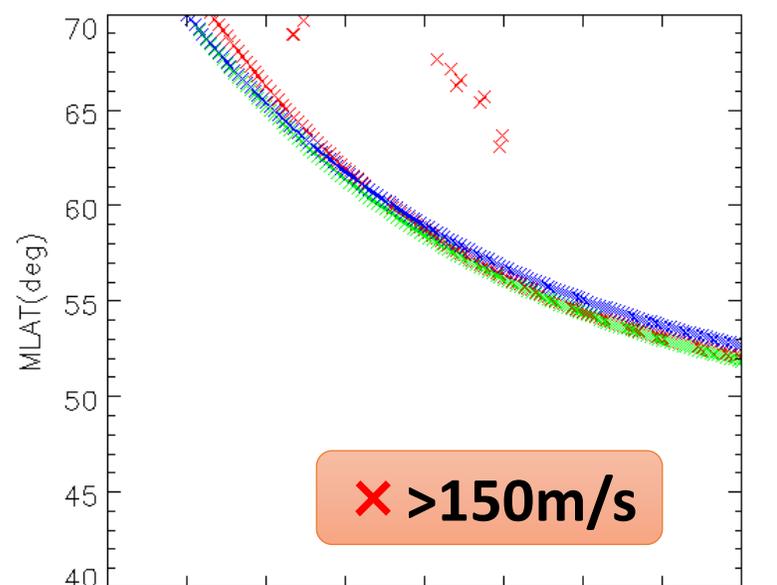
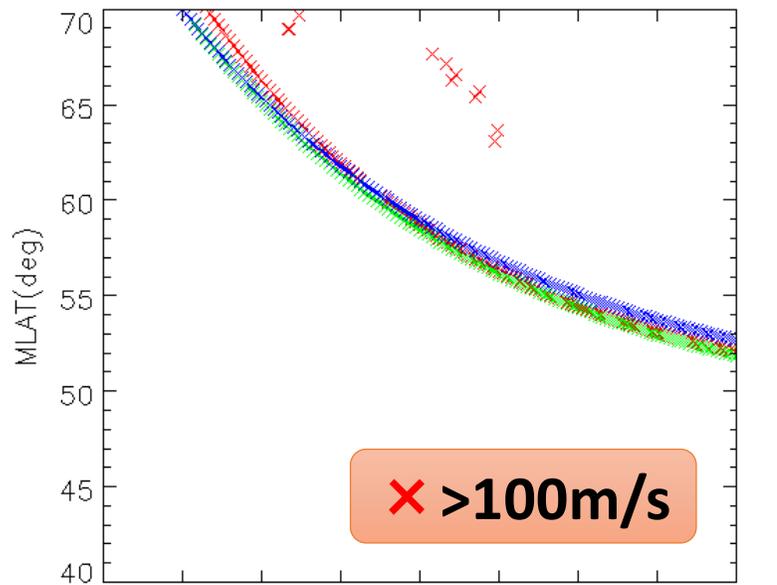
曲線に沿う傾向を持つ集団ともたない集団

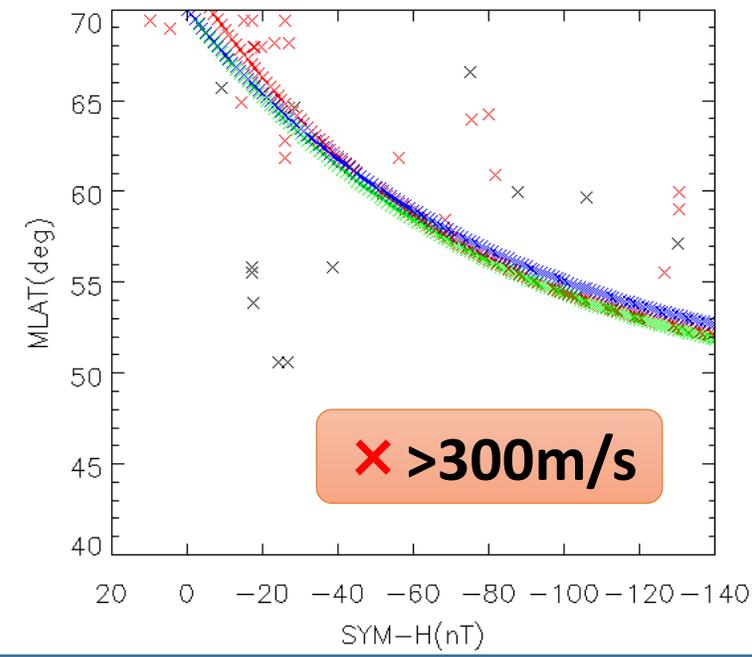
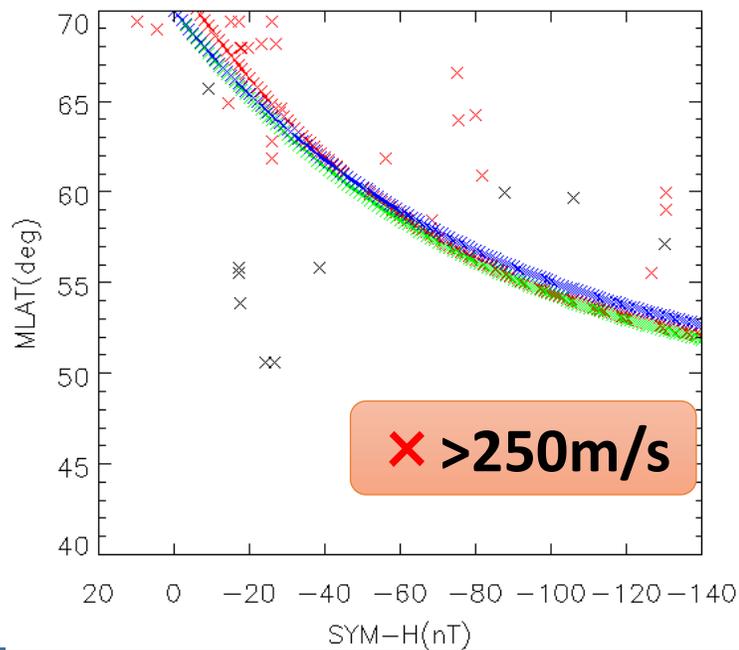
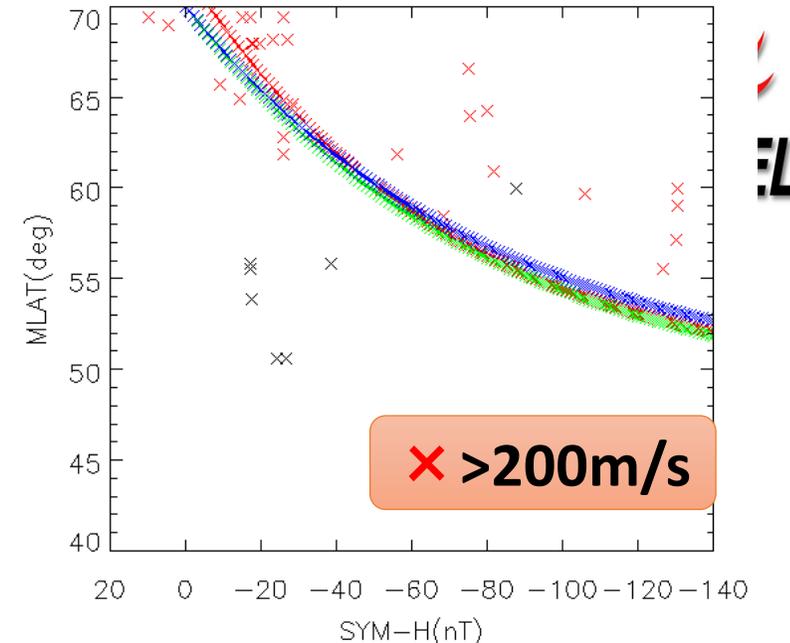
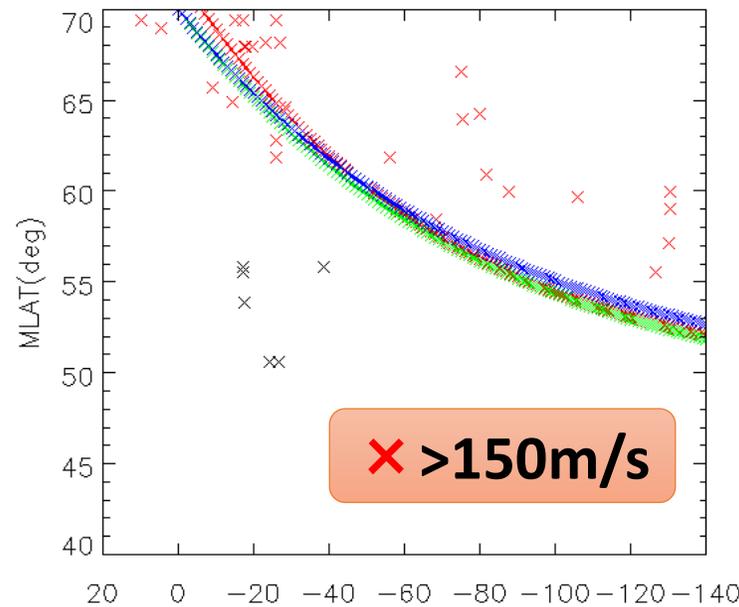
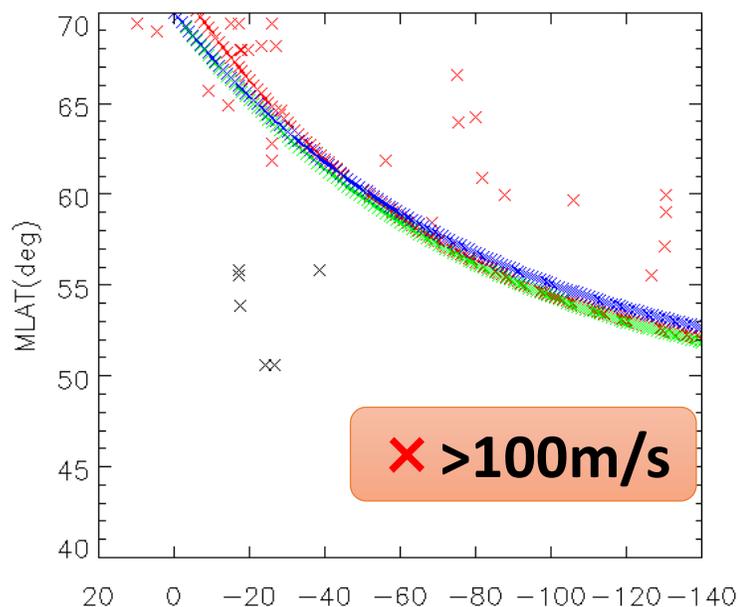


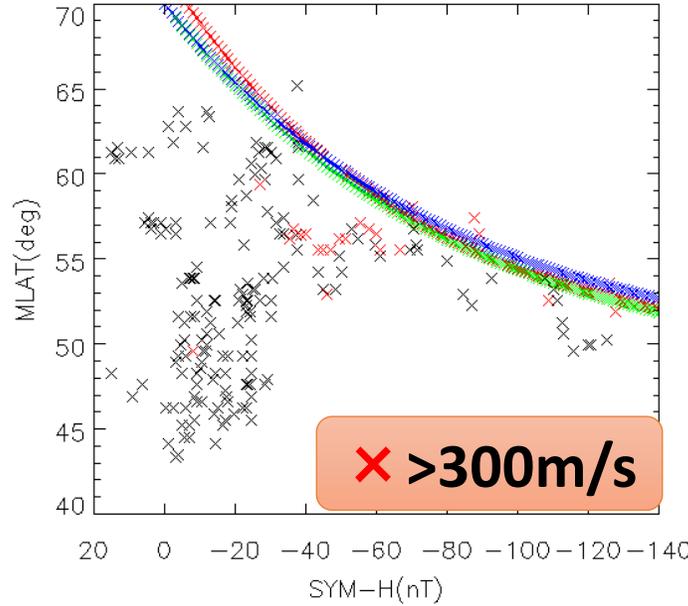
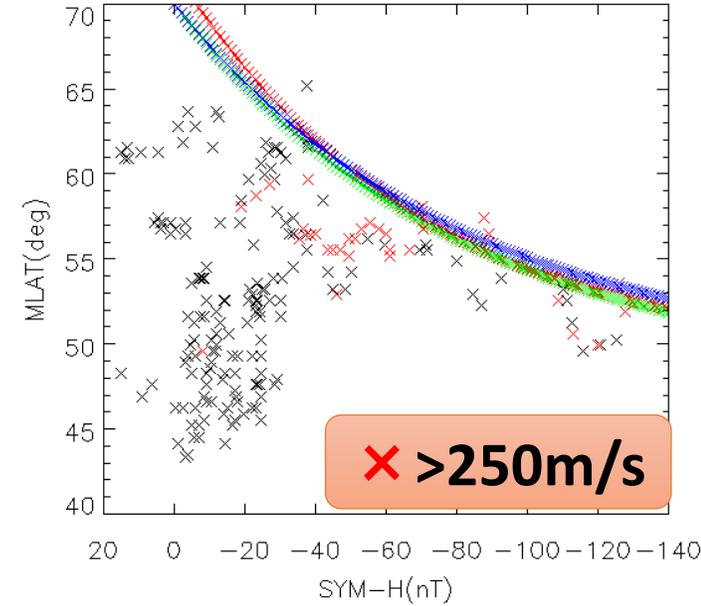
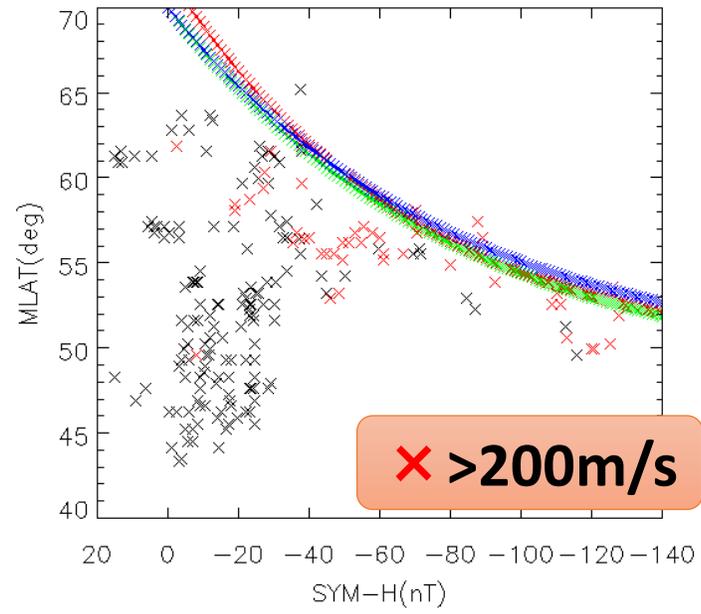
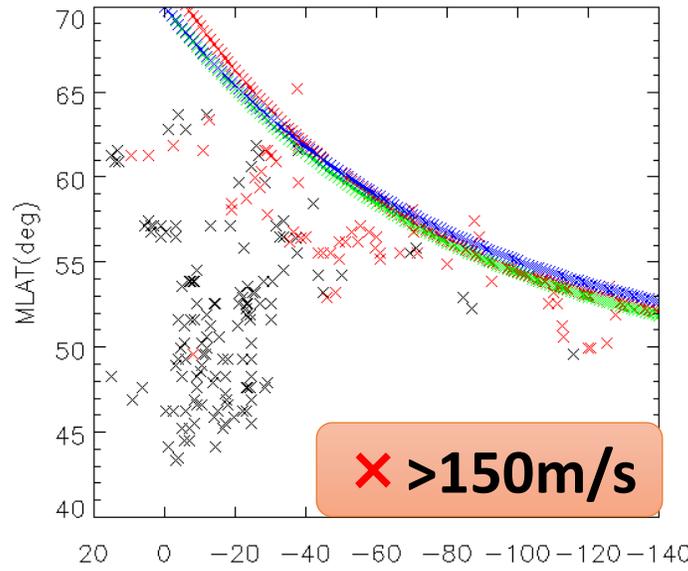
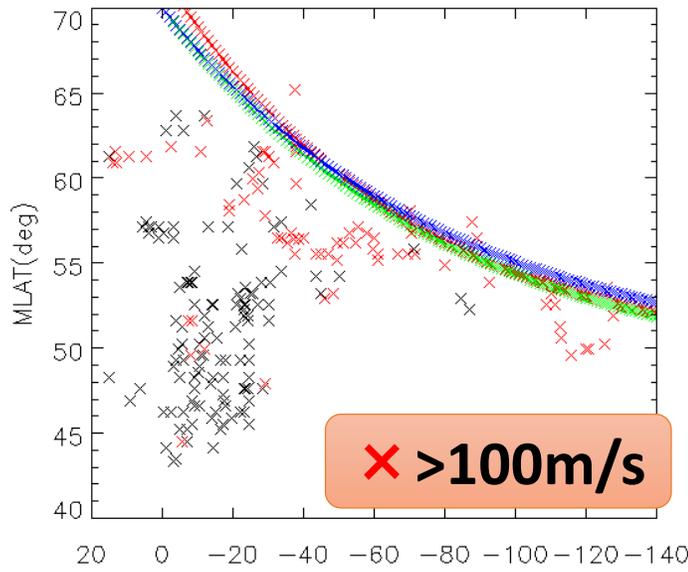
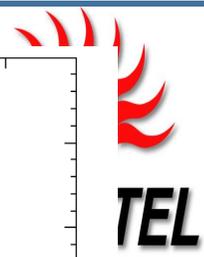
19-22

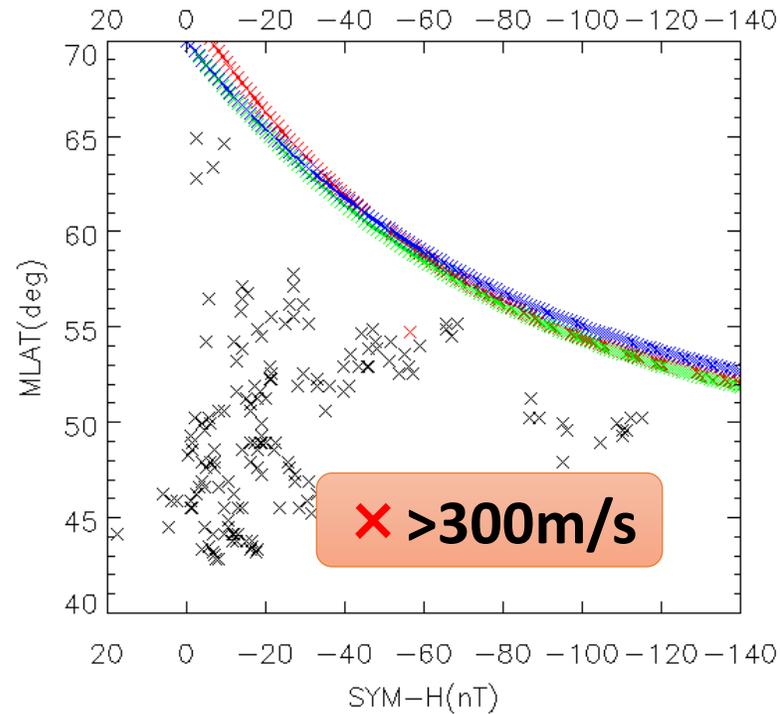
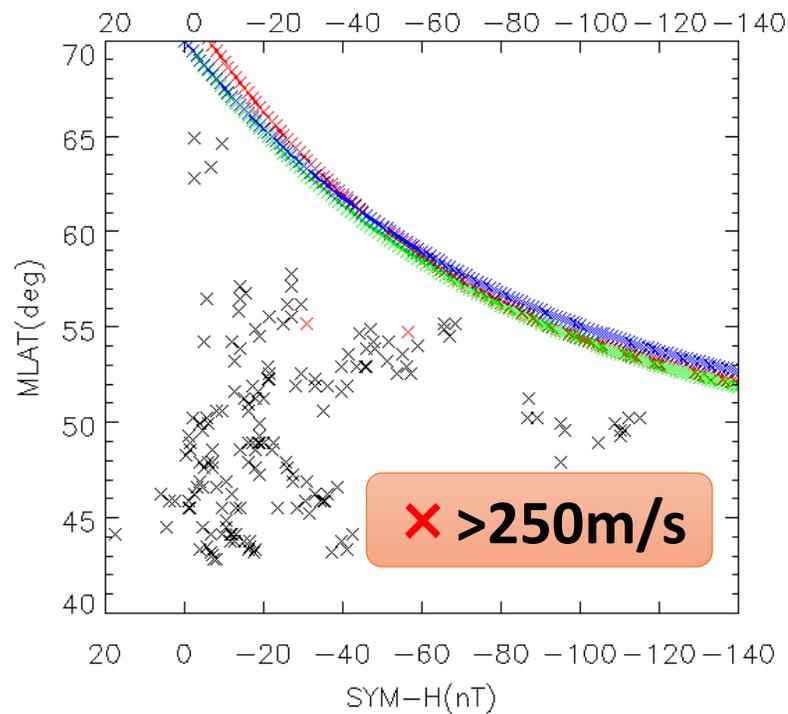
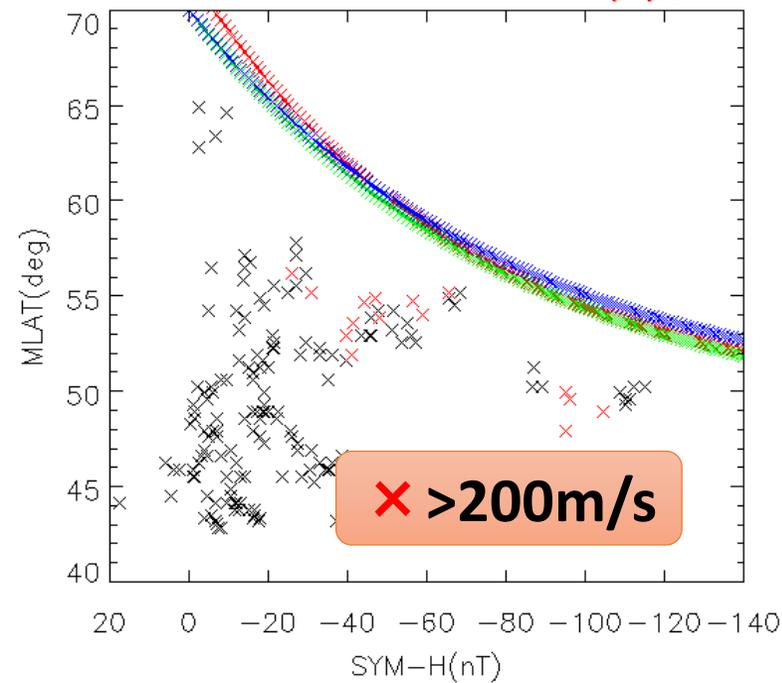
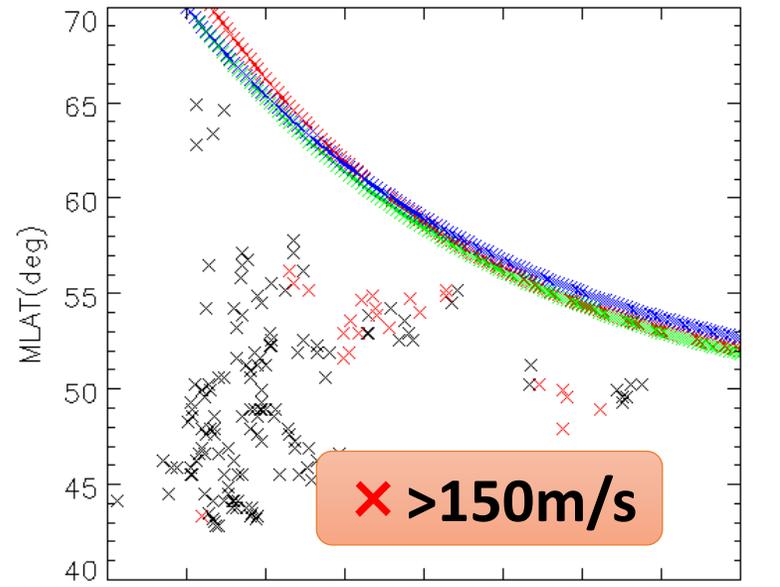
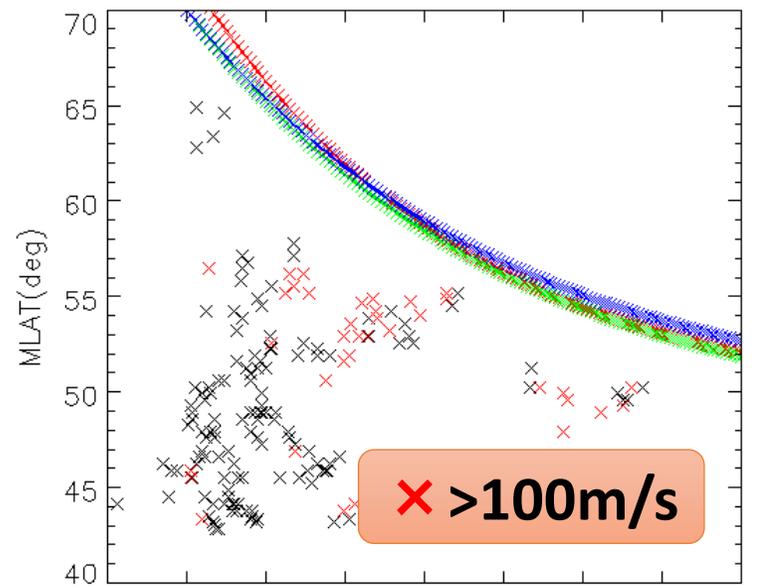


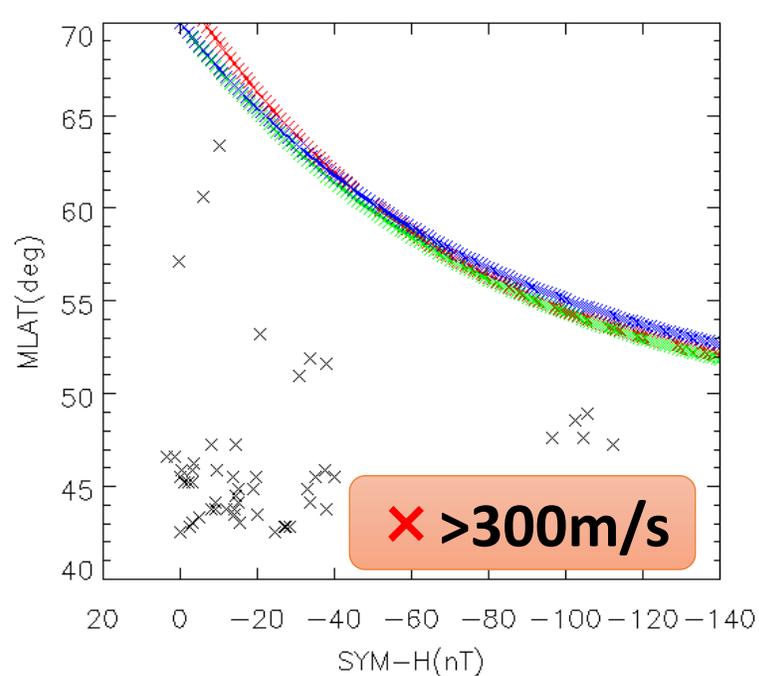
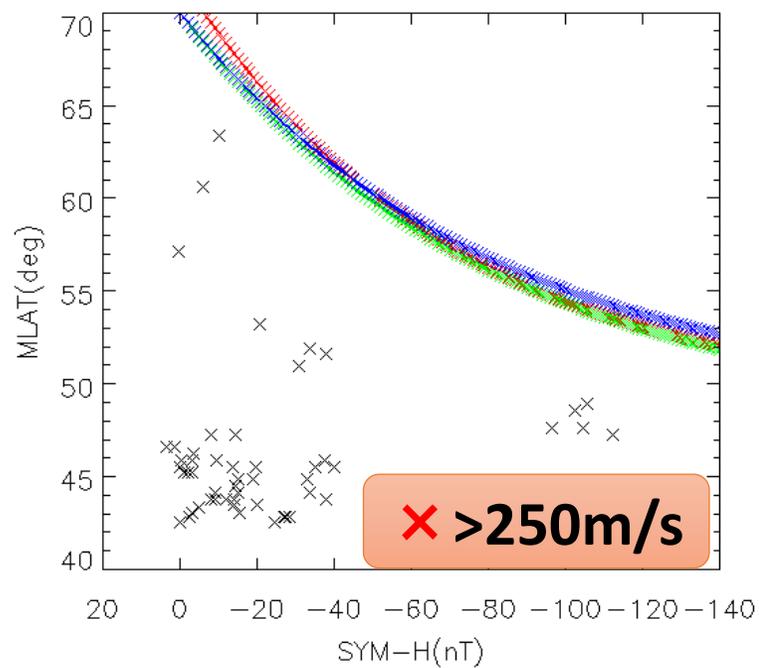
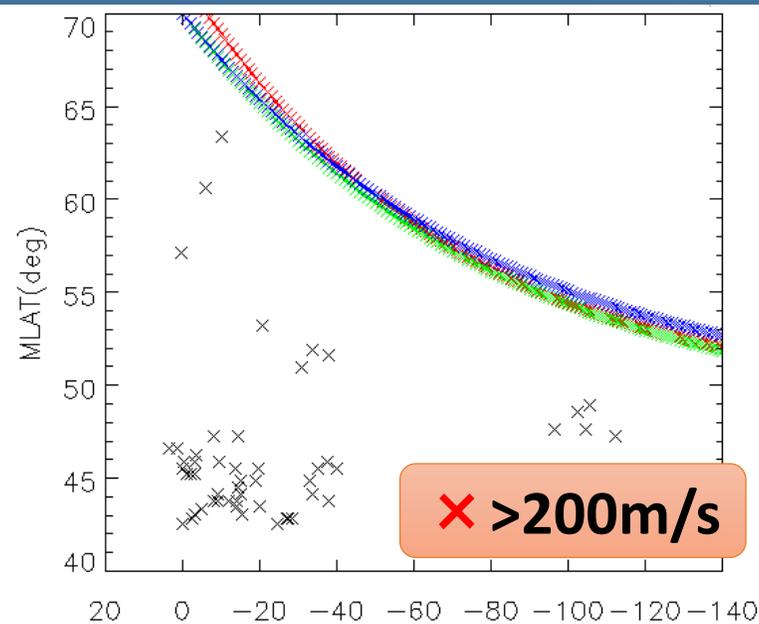
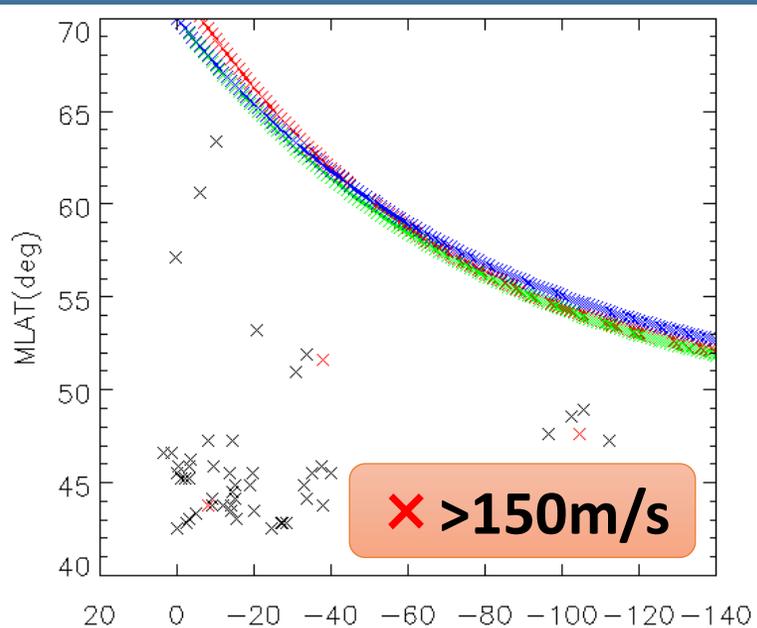
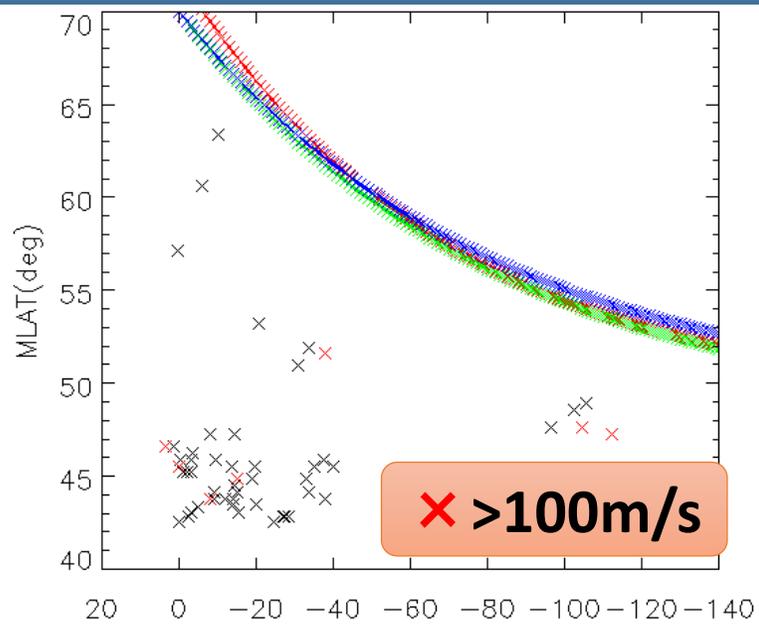
西向き速度150~200m/sで区切ると
曲線に沿った集団と沿わない集団
に分けることが出来る

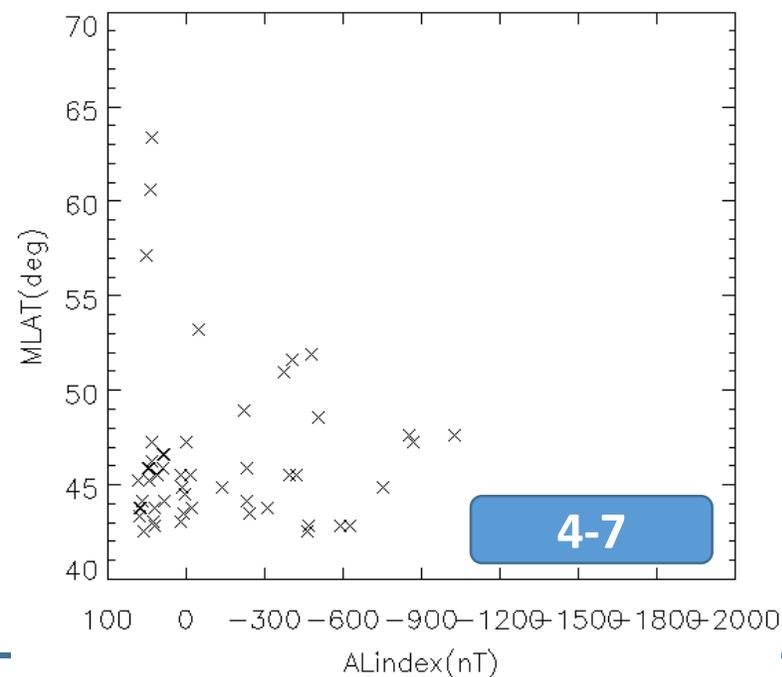
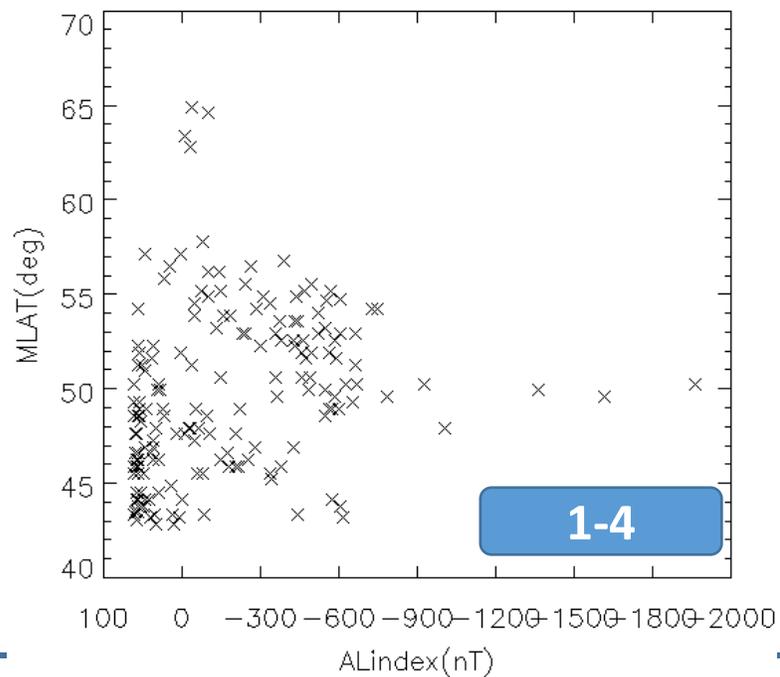
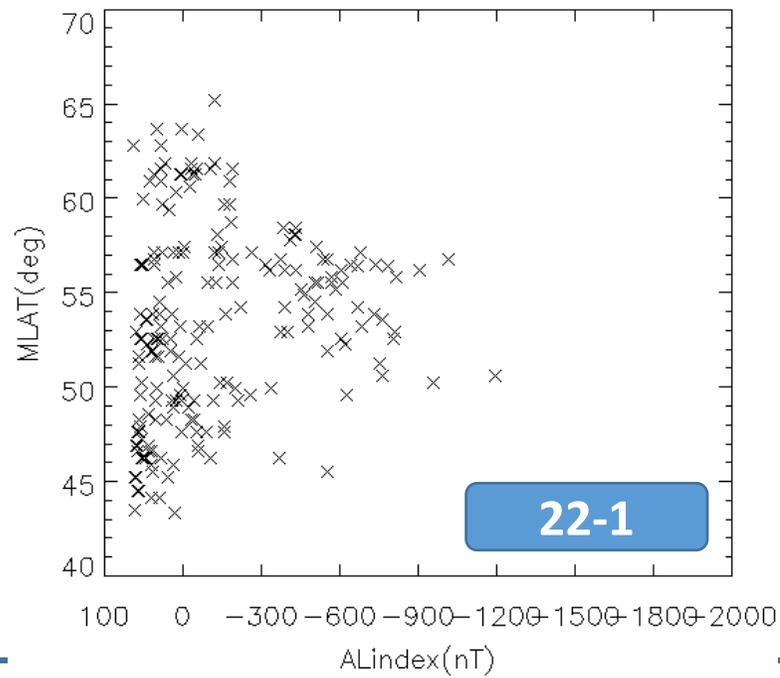
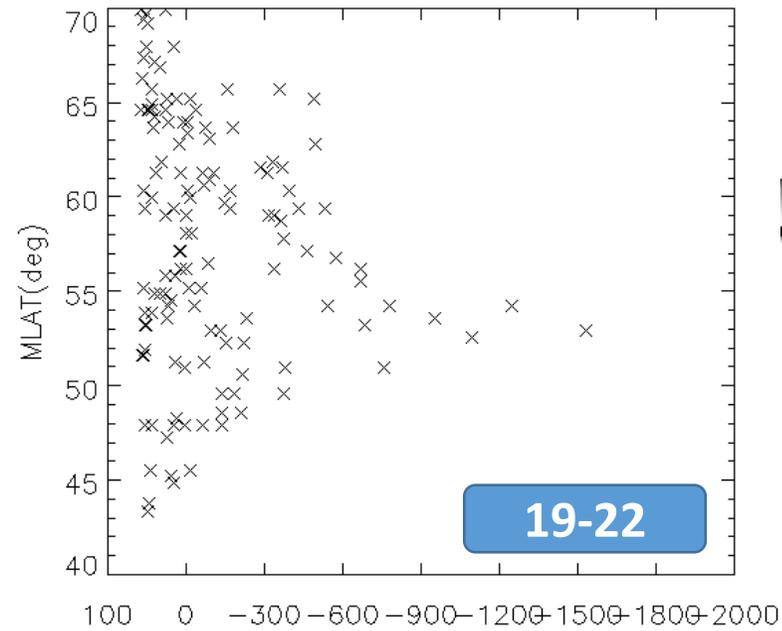
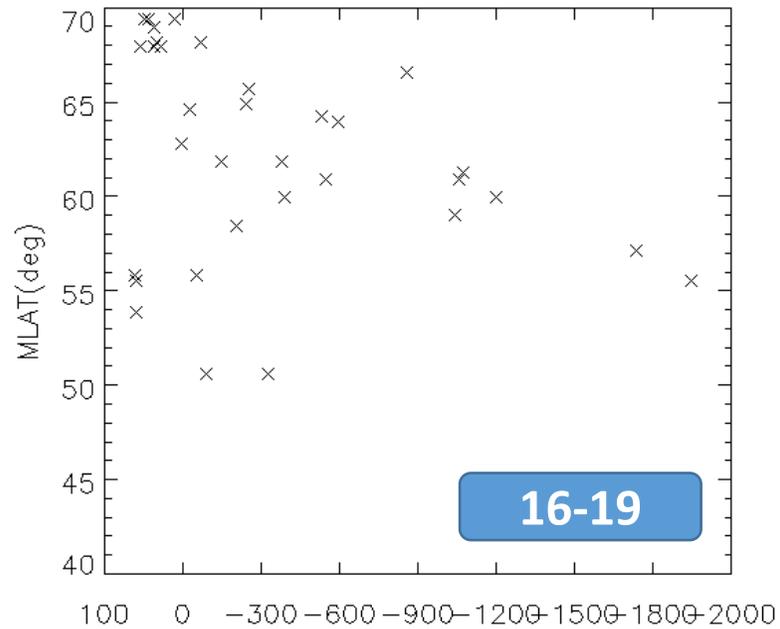
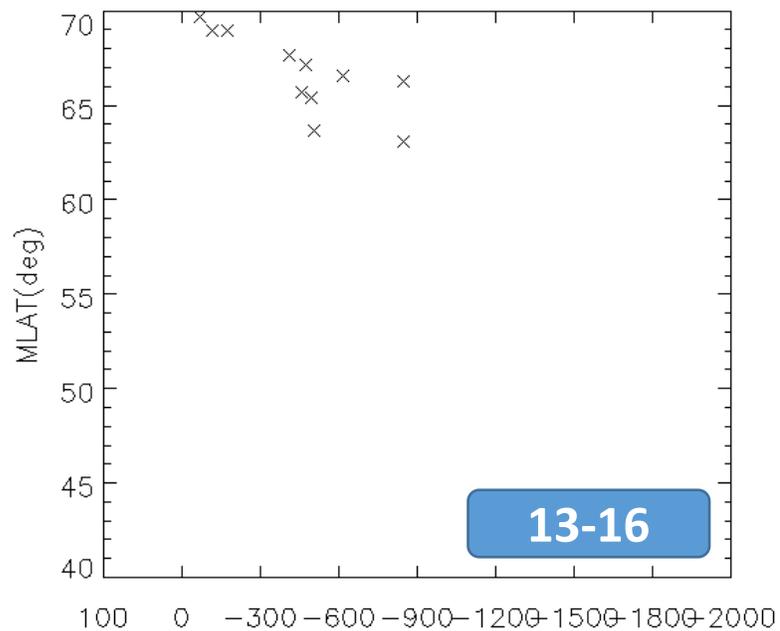


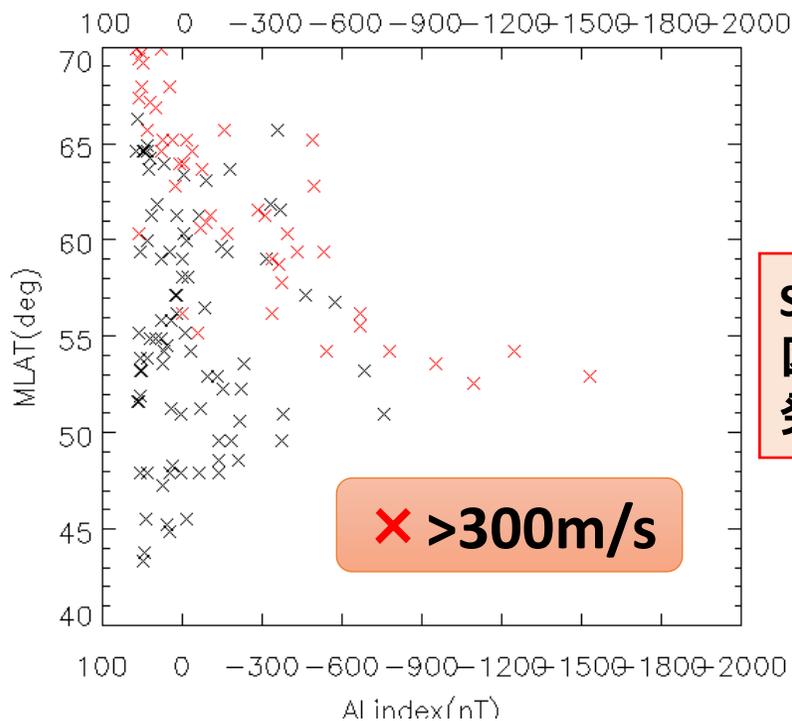
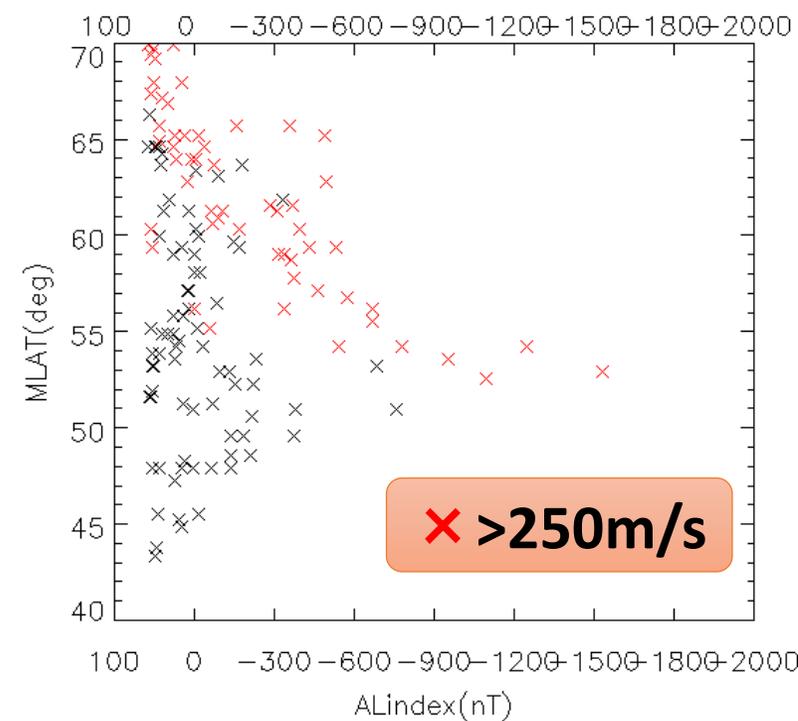
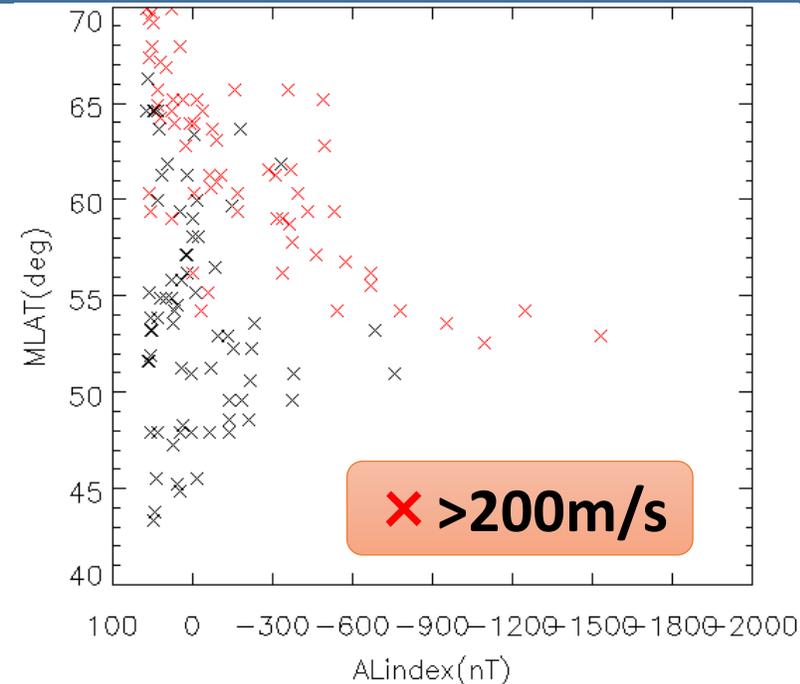
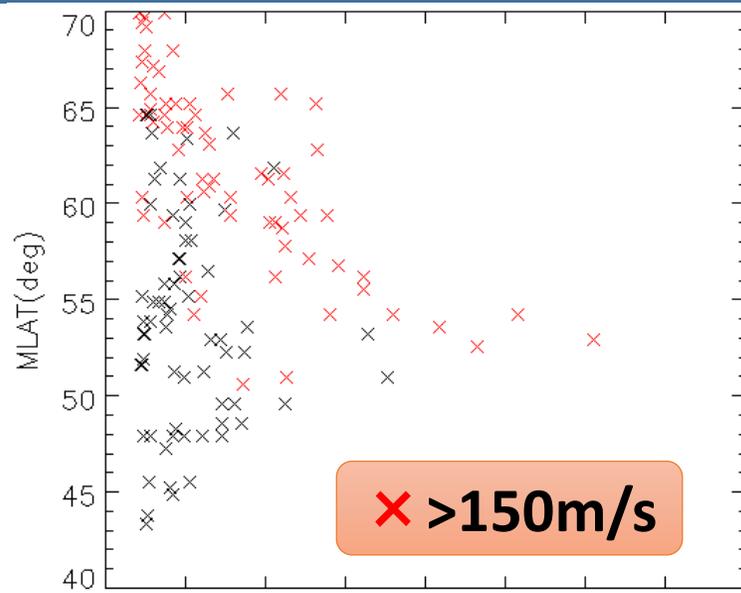
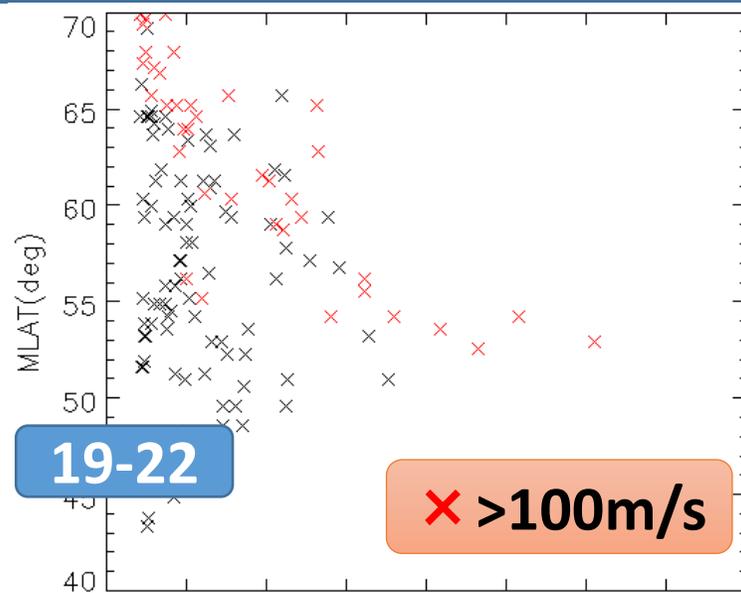




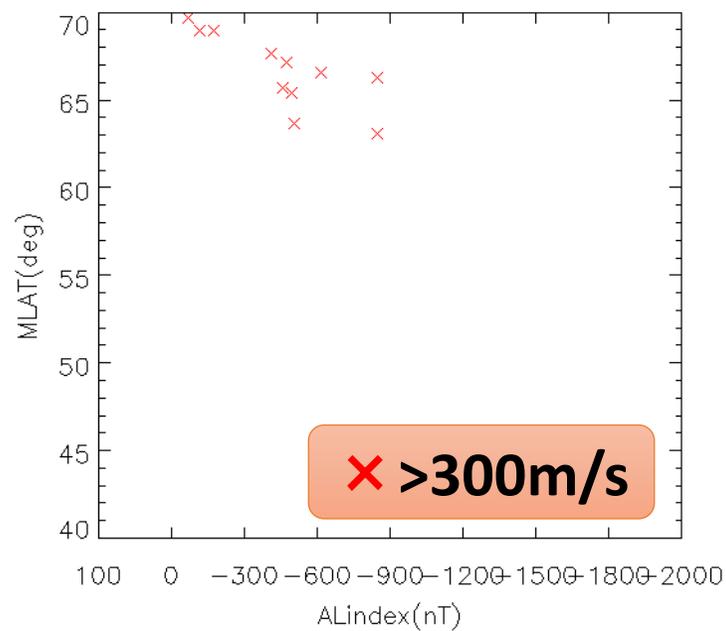
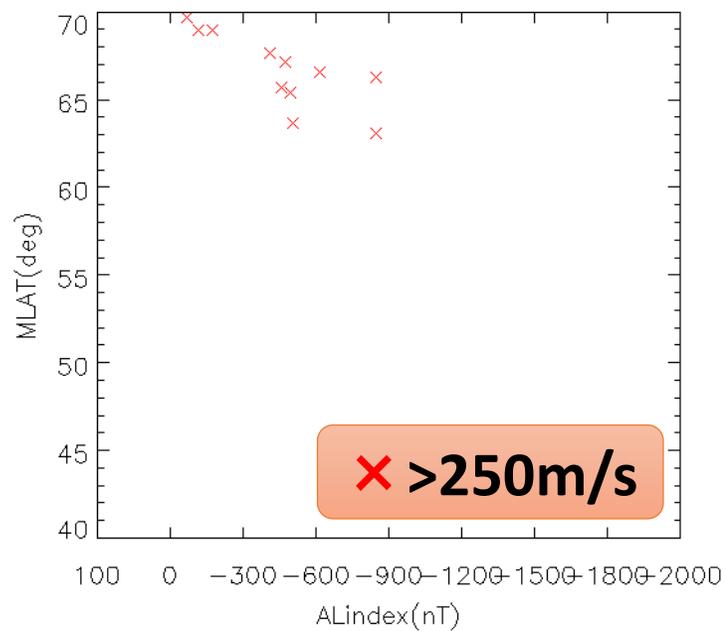
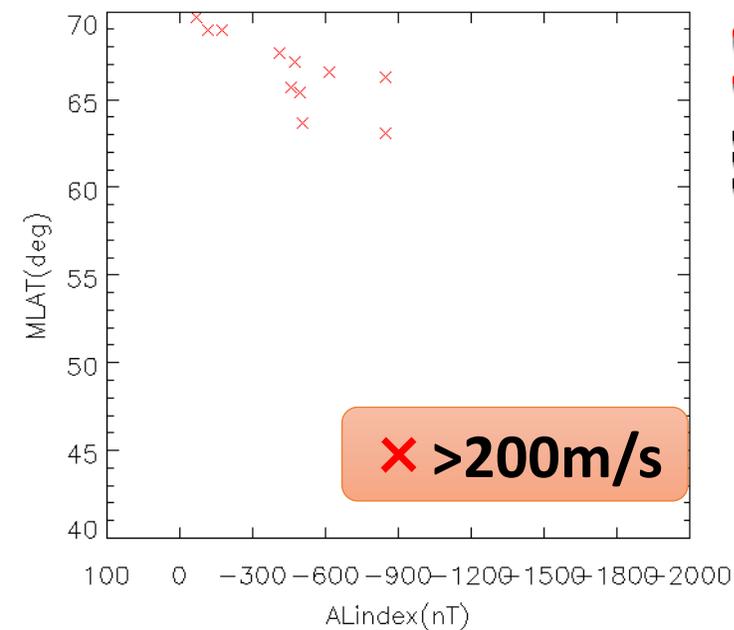
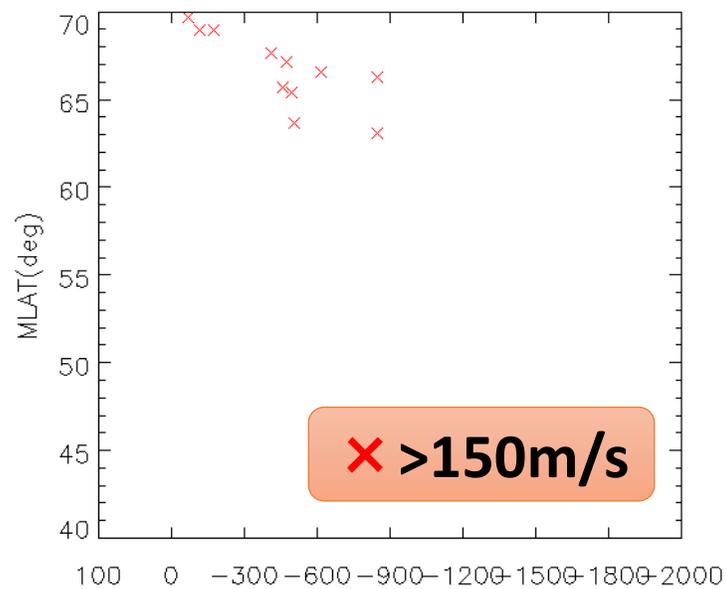
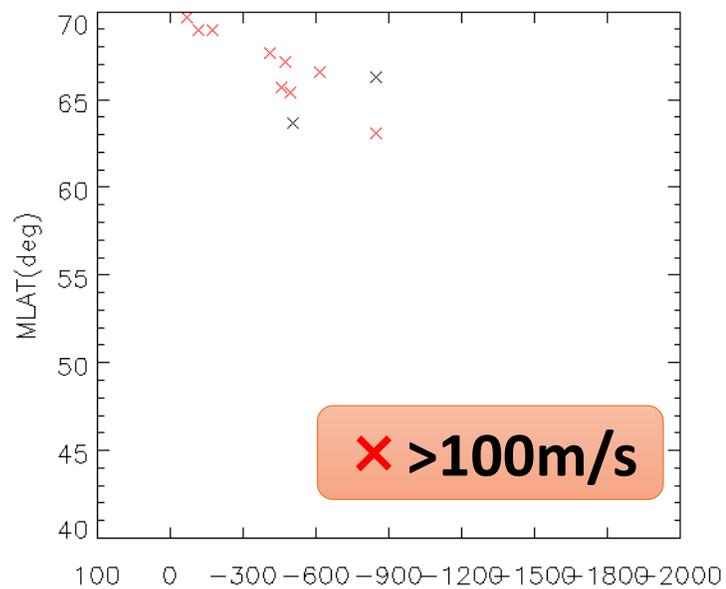


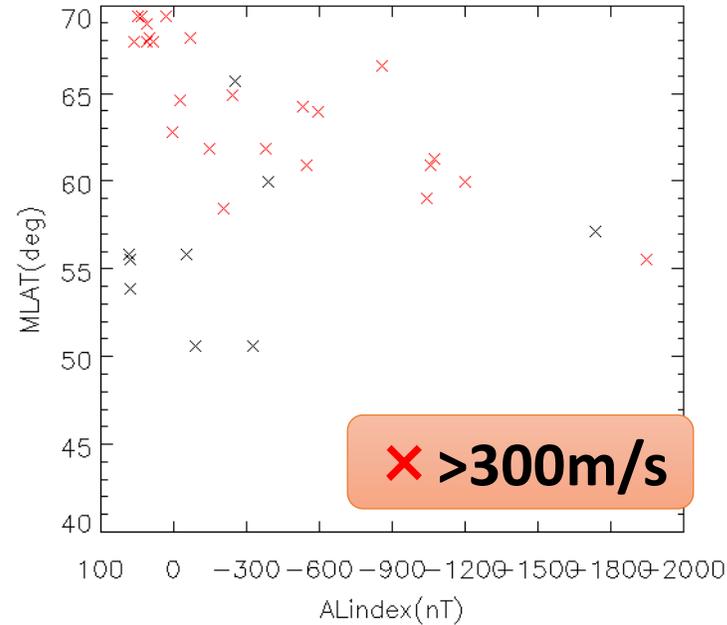
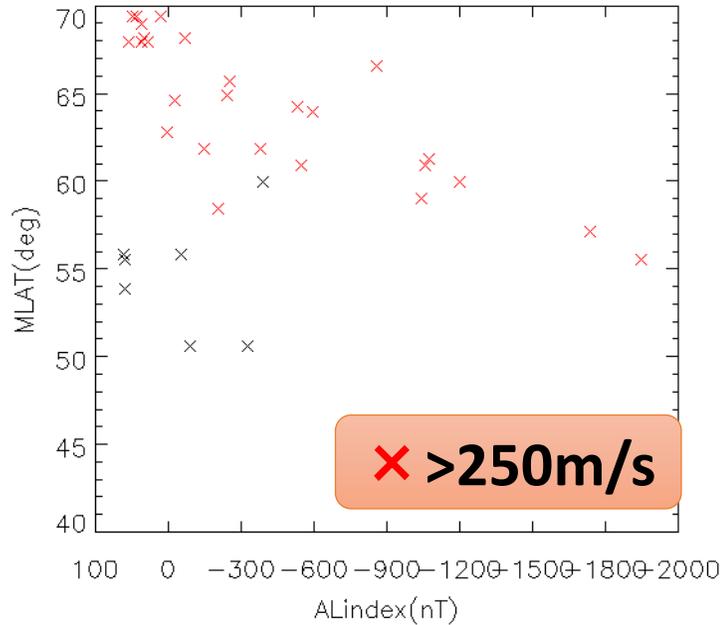
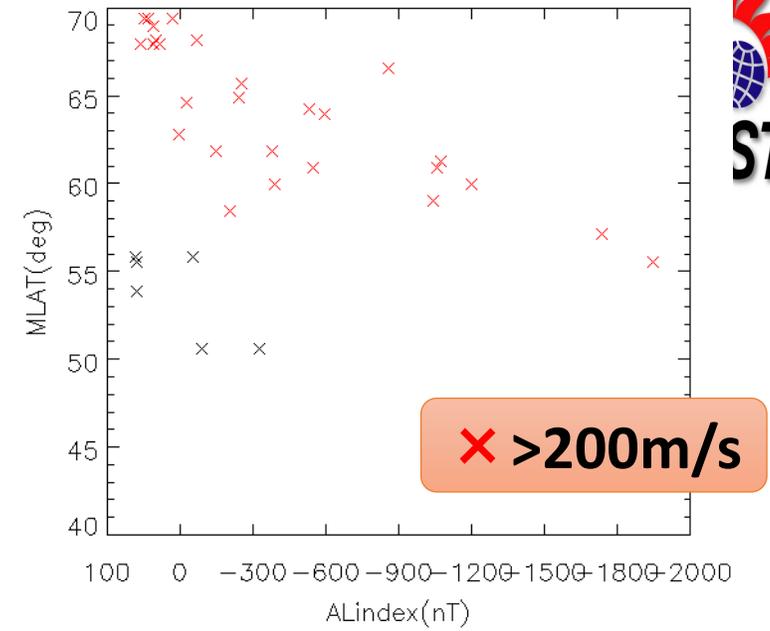
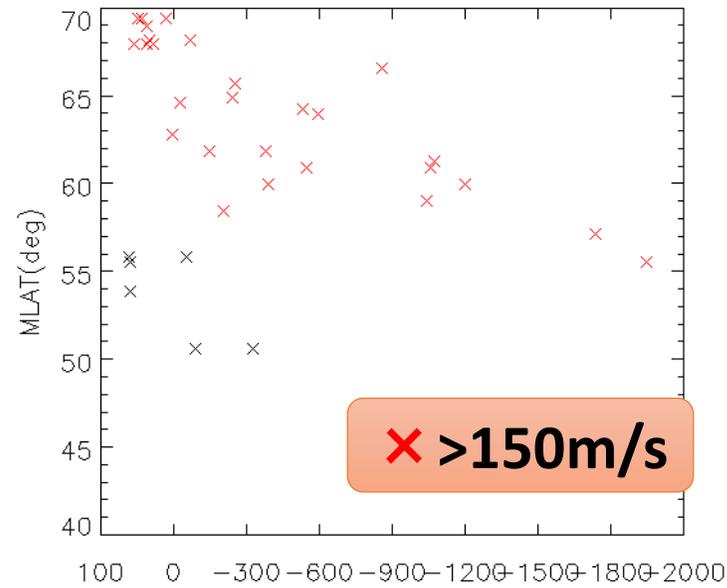
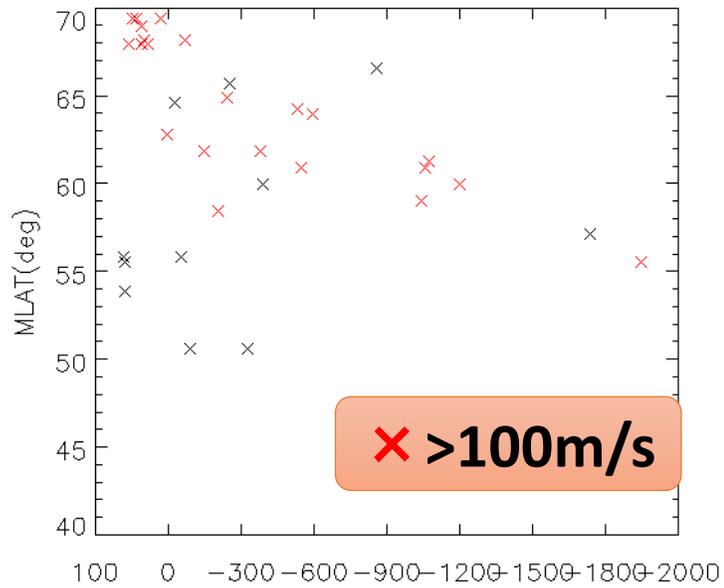


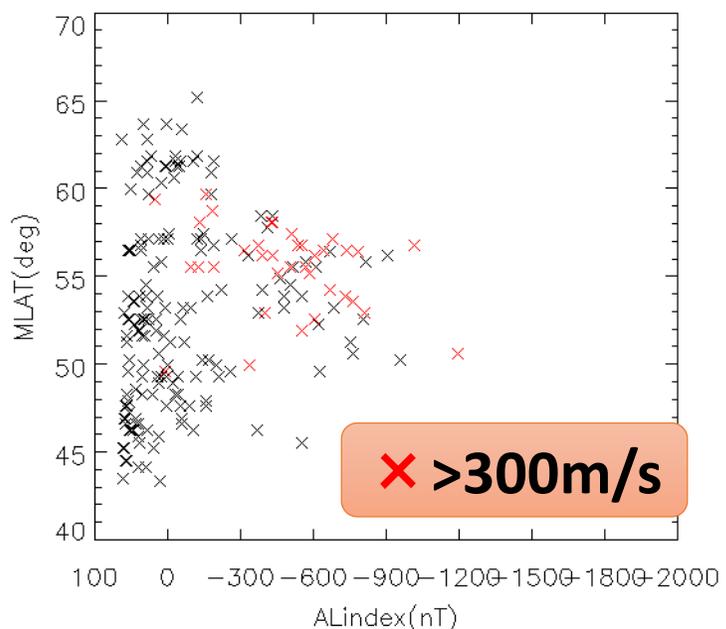
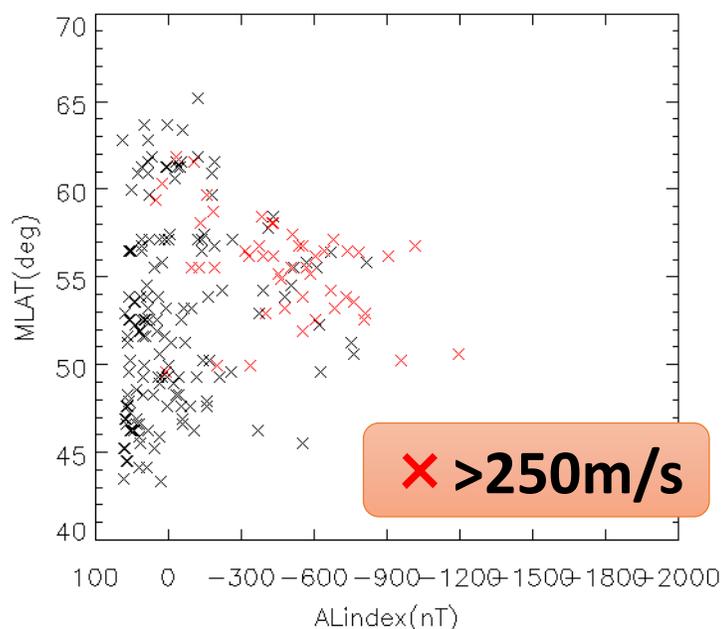
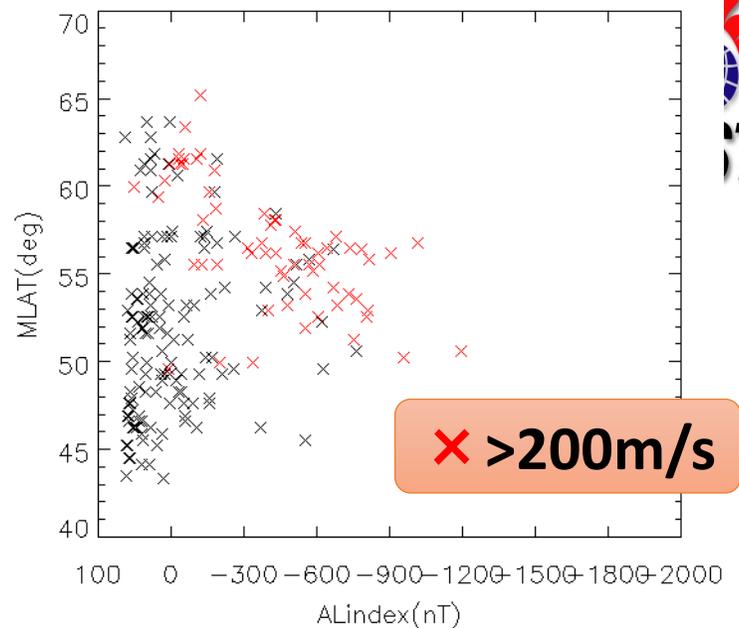
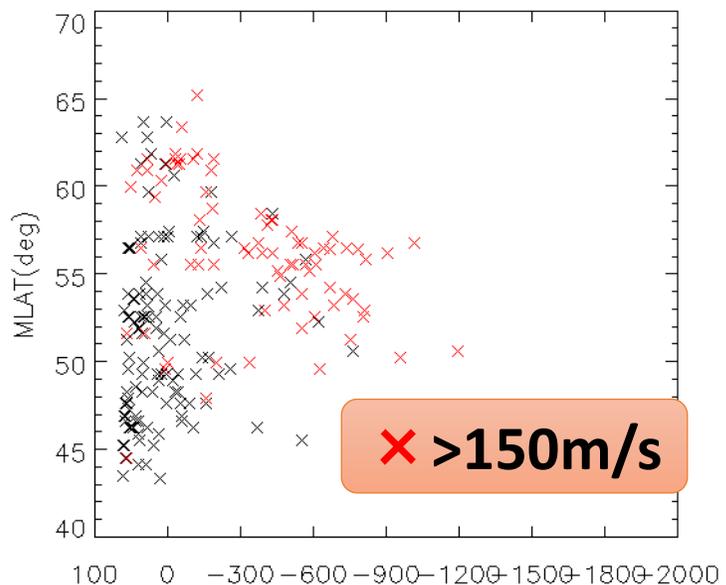
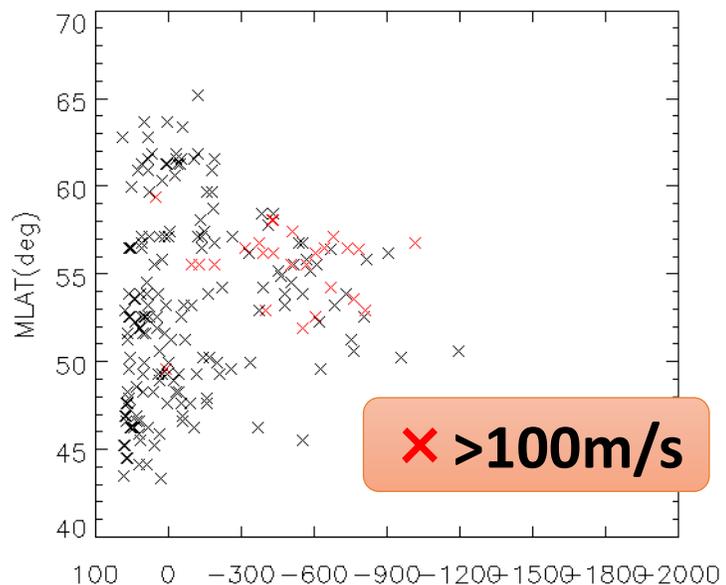


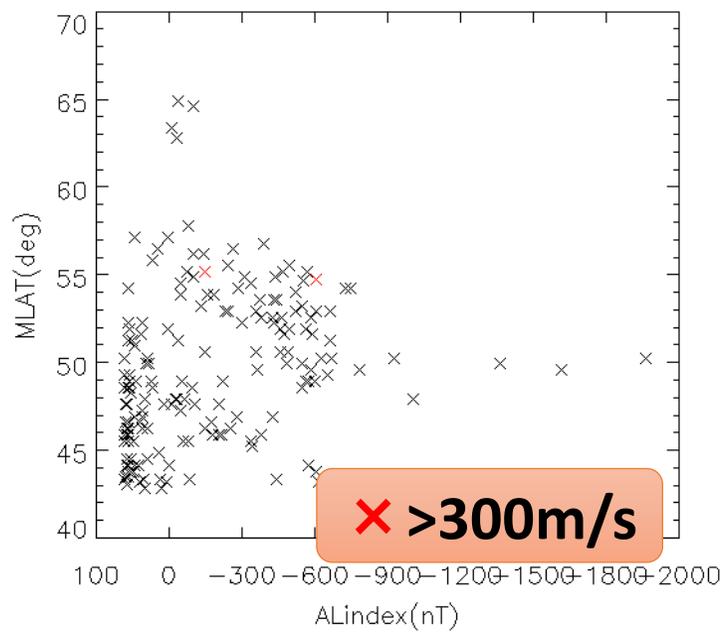
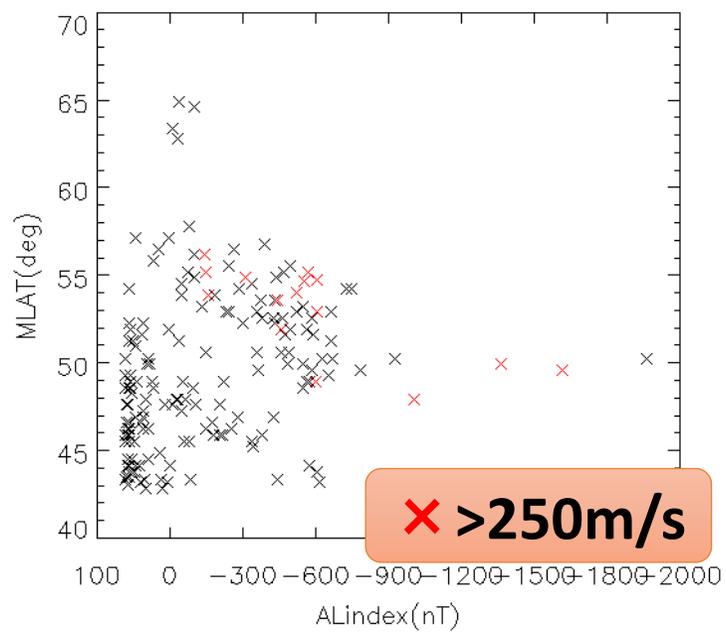
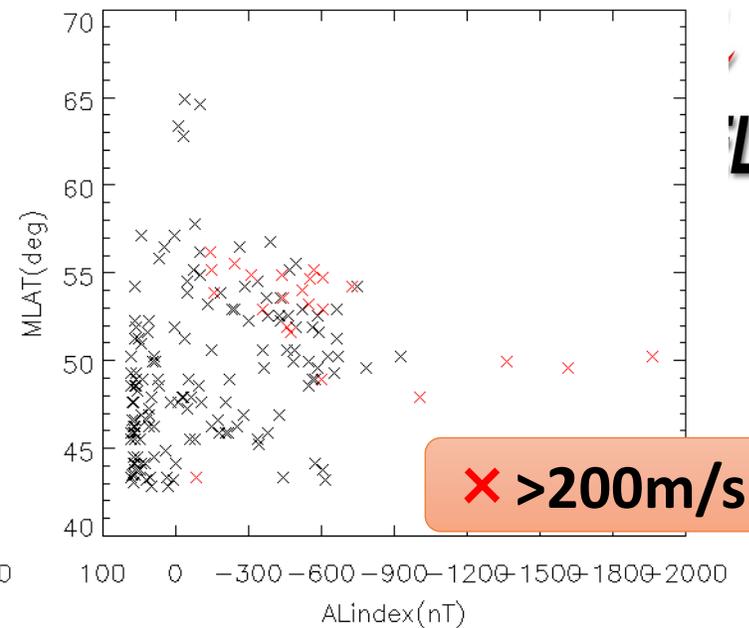
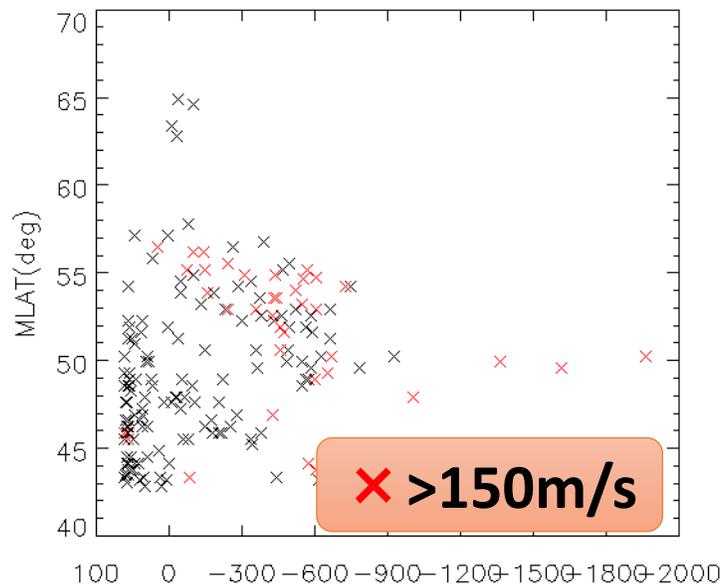
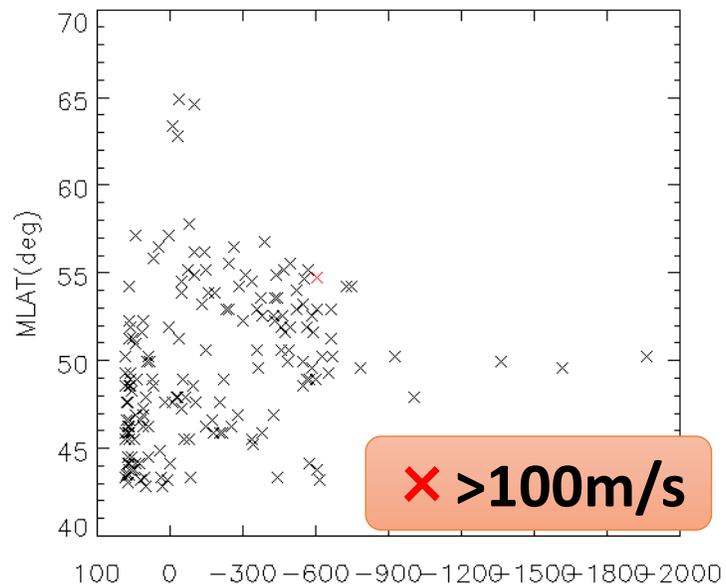


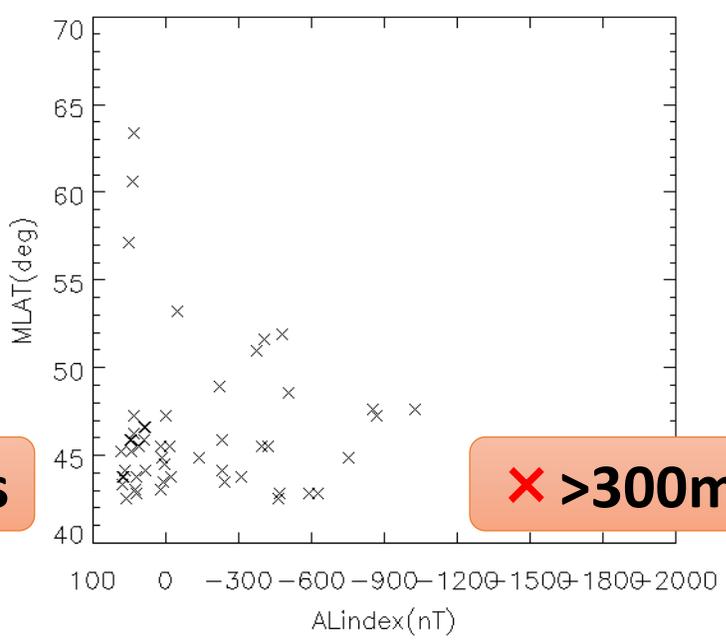
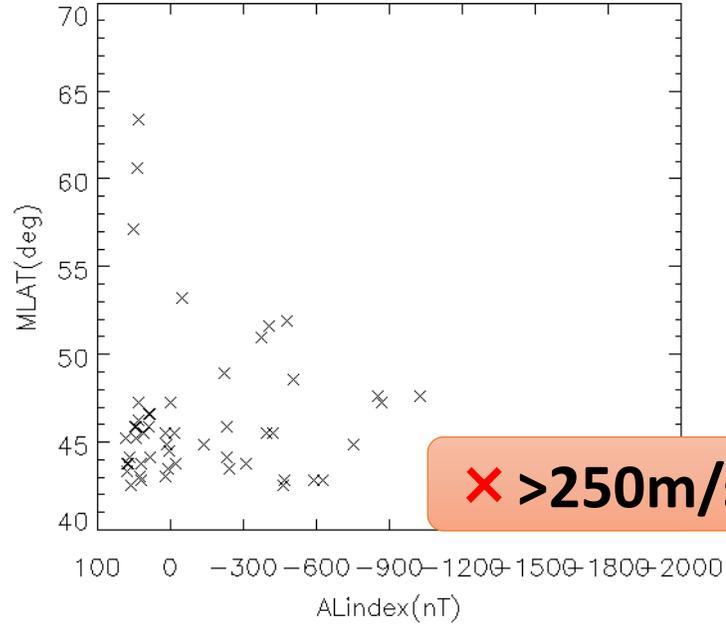
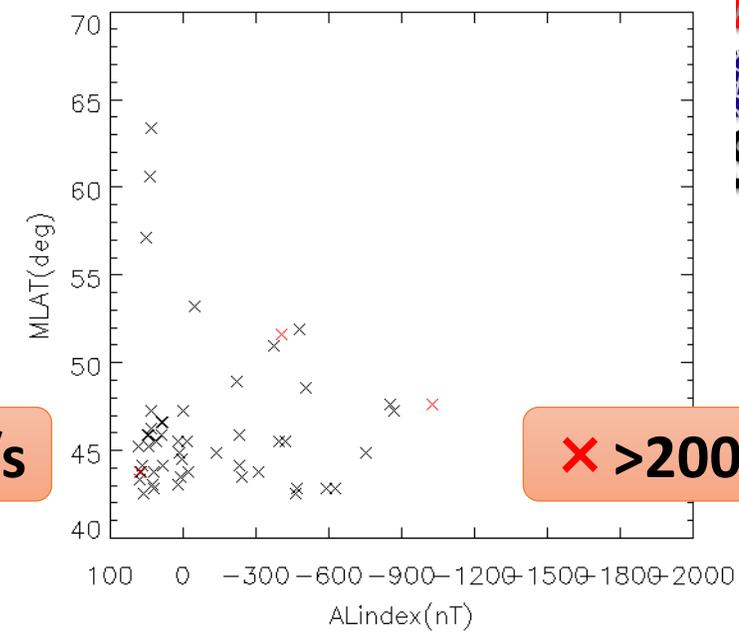
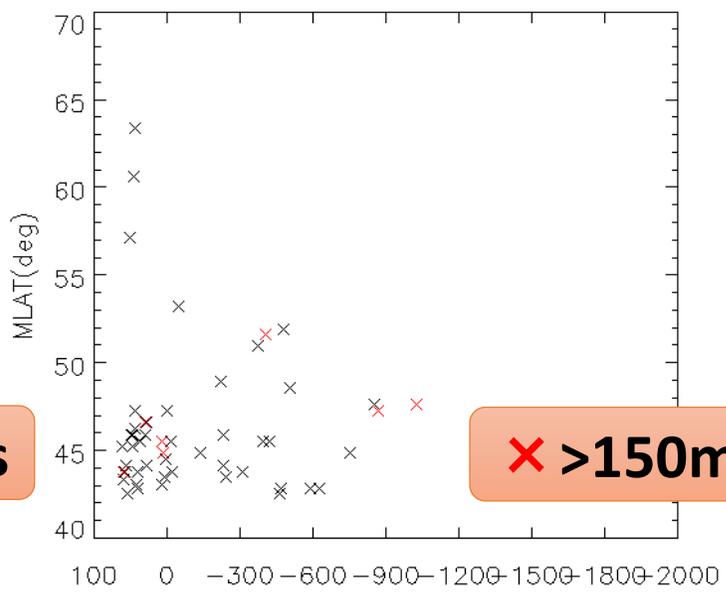
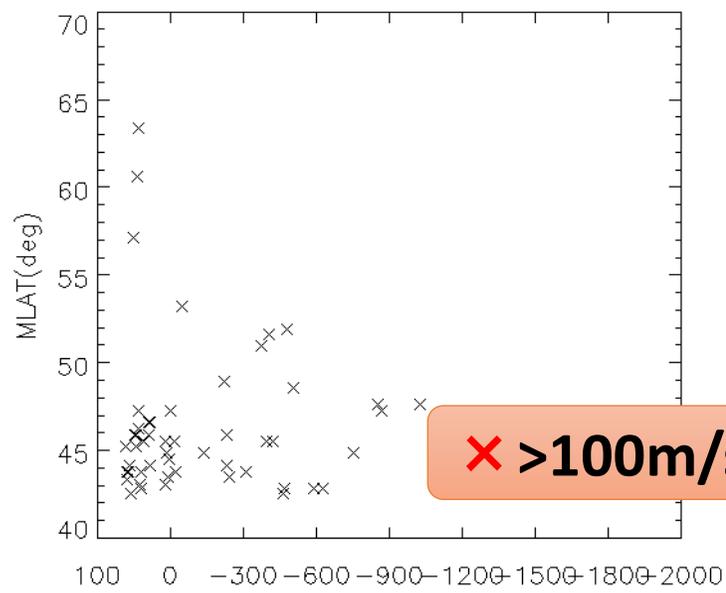
SYM-Hの場合と同様に150~200m/sで区切るとAL指数の減少に伴って発生緯度が低下

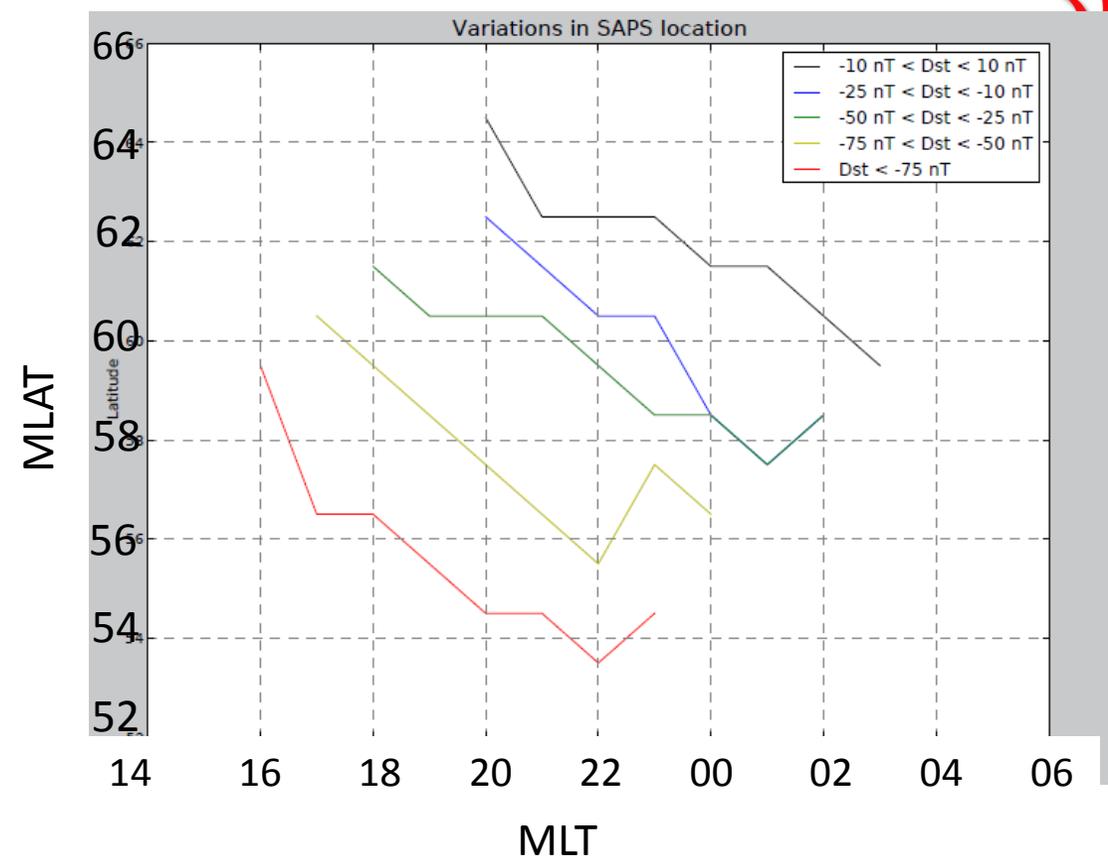
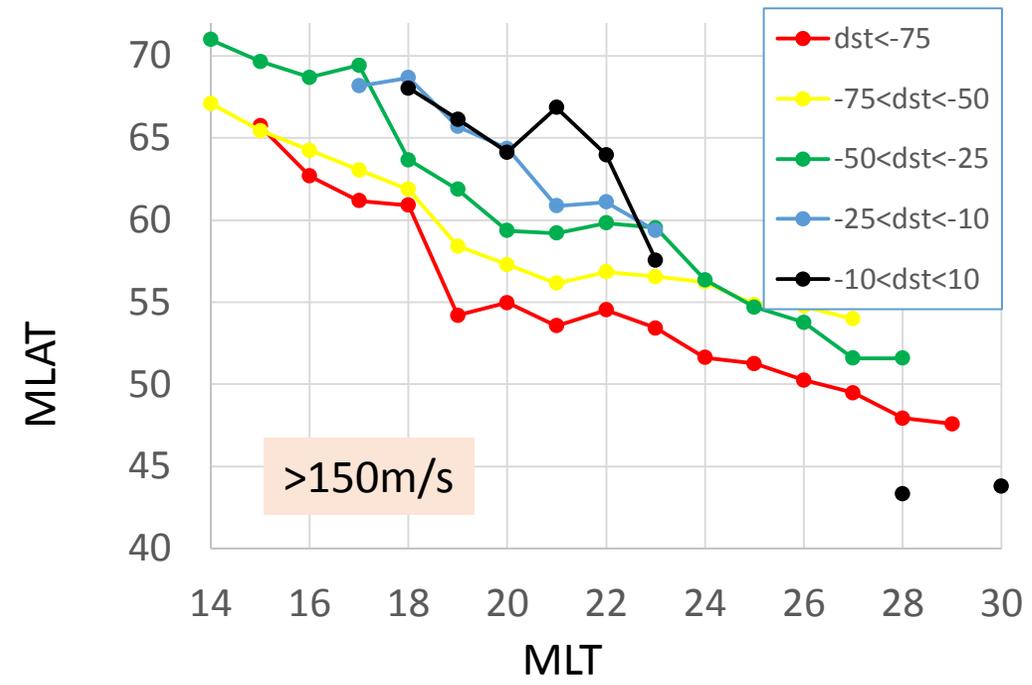
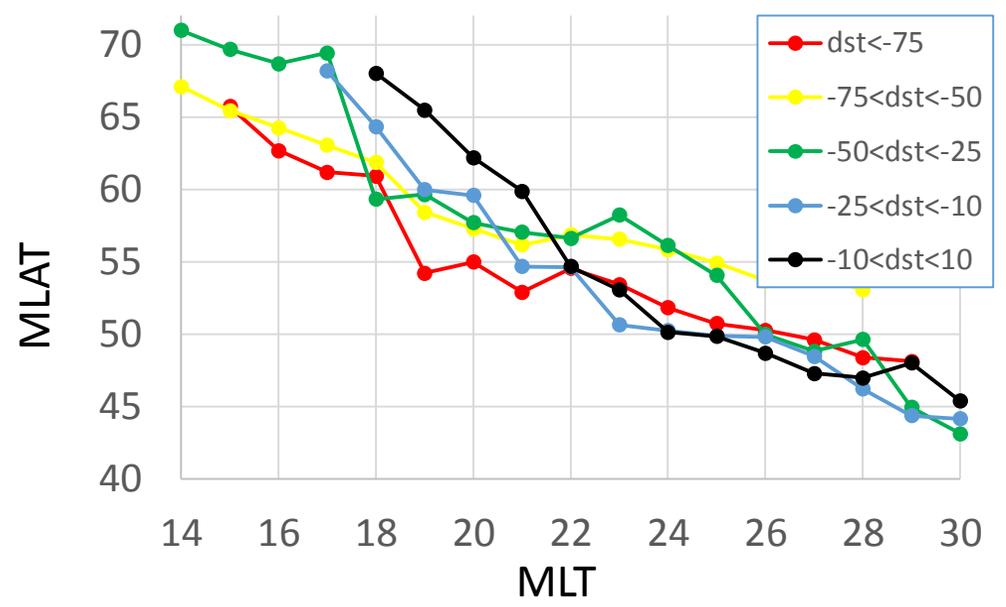






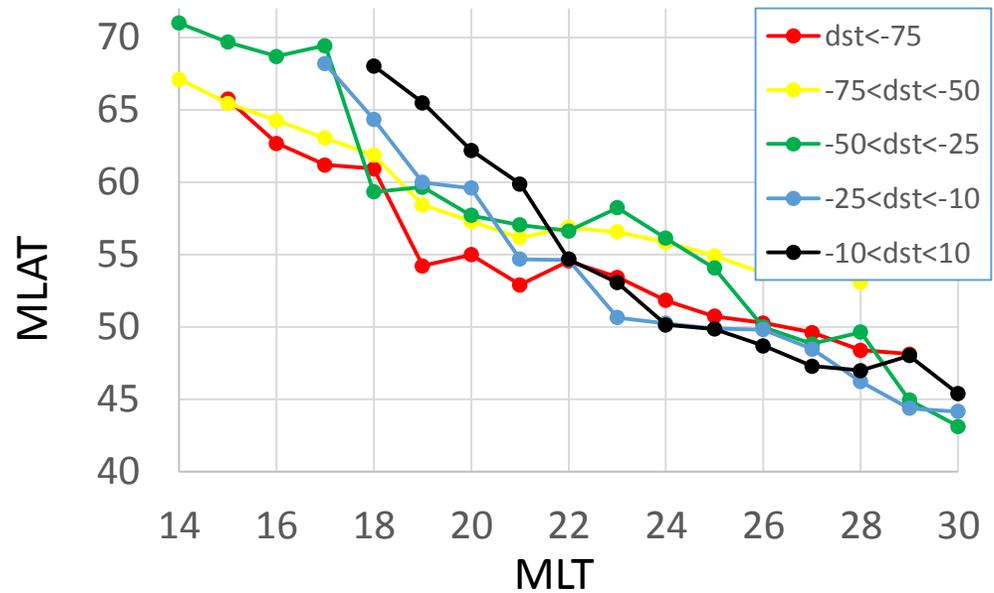
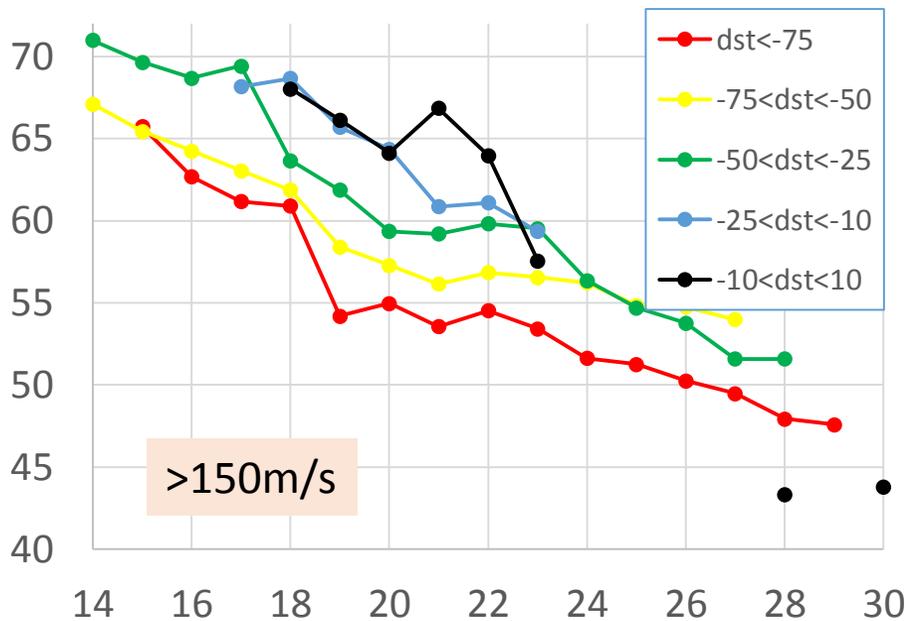
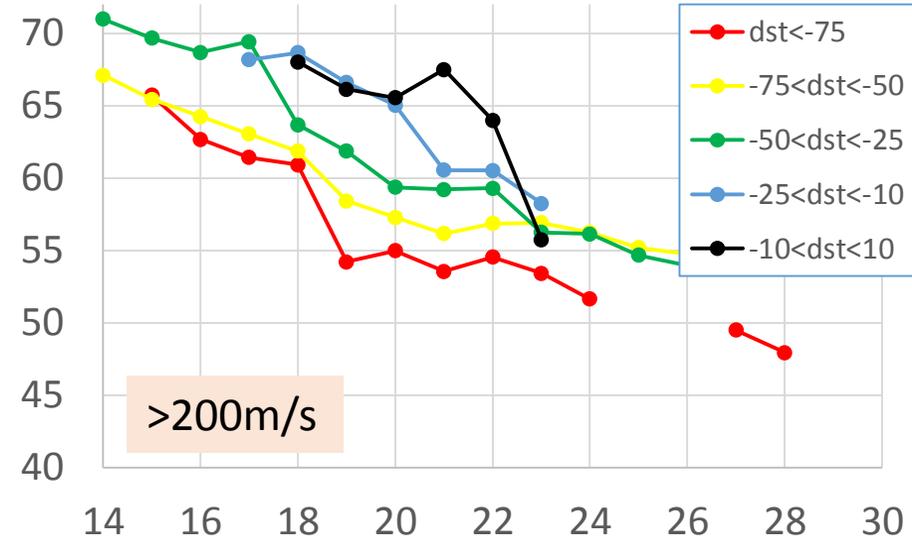
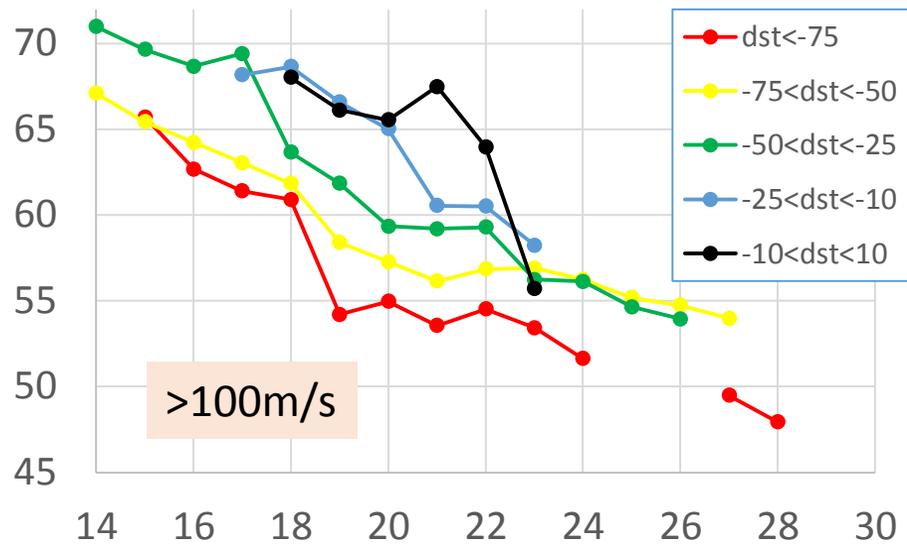






Dst毎のMLTとMLATの関係
 [6]B.Kundri et al.,AGU FALL Meeting 2013.

150m/sで区切ってDst (SYM-H)ごとに時間と緯度の関係を示すとDst毎の差が明確になる



まとめ



これまでの研究より期間、速度、磁気緯度の範囲を大きくとり
SAPS(西向きプラズマ対流)とSYM-H,AL指数の依存性を調査

・速度150~200m/s付近を閾値としてサブオーロラ帯西向きプラズマ対流の特性が異なるということが見出された。

- ✓ 閾値より速いものはSAPSに見られるSYM-Hと緯度の依存性が得られた
- ✓ 閾値以下のものはSYM-Hと緯度に関連性が見られなかった
- ✓ AL指数と発生緯度にも相関が見られた



SAPS発生メカニズムを明らかにする上での手がかり

今後



・下限の物理的仕組みの調査

- ✓ SAPSとパラメータの時間差による関係性の調査
- ✓ 速度、緯度と発生特性のより詳細な関係の確認

・フェーズによる依存性の違いの確認

- ✓ 今回のデータをフェーズごとに区分し相関を調査する

・AL指数と発生緯度の関係性の調査