Simmons, Alisha M. (MSFC-NAS802002)[MAINTHIA]

From: Summers, Freda G. (MSFC-VP60) [Freda.Summers@mail.nsstc.nasa.gov]
Sent: Monday, October 15, 2007 11:45 AM
To: Simmons, Alisha M. (MSFC-NAS802002)[MAINTHIA]
Subject: FW: 1676 request

From: Gallagher, Dennis L. (MSFC-VP62) [mailto:dennis.gallagher@nasa.gov]
Sent: Monday, October 15, 2007 11:34 AM
To: Summers, Freda G. (MSFC-VP60)
Subject: RE: 1676 request

Freda,

This was supplied long ago by either Patrisha or Beth. I don't know to whom it was given, but I know it was provided. Here it is again however.

Dennis

2-D Drift Velocities from the IMAGE EUV Plasmaspheric Imager

D. L. Gallagher and M. L. Adrian

The IMAGE Mission extreme ultraviolet imager (EUV) observes He^+ plasmaspheric ions throughout the inner magnetosphere. Limited by ionizing radiation and viewing close to the Sun, images of the He^+ distribution are available every 10 minutes for many hours as the spacecraft passes through apogee in its highly elliptical orbit. As a consistent constituent at about 15%, He^+ is an excellent surrogate for monitoring all of the processes that control the dynamics of plasmaspheric plasma. In particular, the motion of He^+ transverse to the ambient magnetic field is a direct indication of convective electric fields. The analysis of boundary motions has already achieved new insights into the electrodynamic coupling processes taking place between energetic magnetospheric plasmas and the ionosphere. Yet to be fulfilled, however, is the original promise that global EUV images of the plasmasphere might yield two-dimensional pictures of meso-scale to macro-scale electric fields in the inner magnetosphere. This work details the technique and initial application of an IMAGE EUV analysis that appears capable of following thermal plasma motion on a global basis.

From: Summers, Freda G. (MSFC-VP60) [mailto:Freda.Summers@mail.nsstc.nasa.gov]
Sent: Monday, October 15, 2007 10:20 AM
To: Gallagher, Dennis L. (MSFC-VP62)
Subject: FW: 1676 request

Dr. Gallagher:

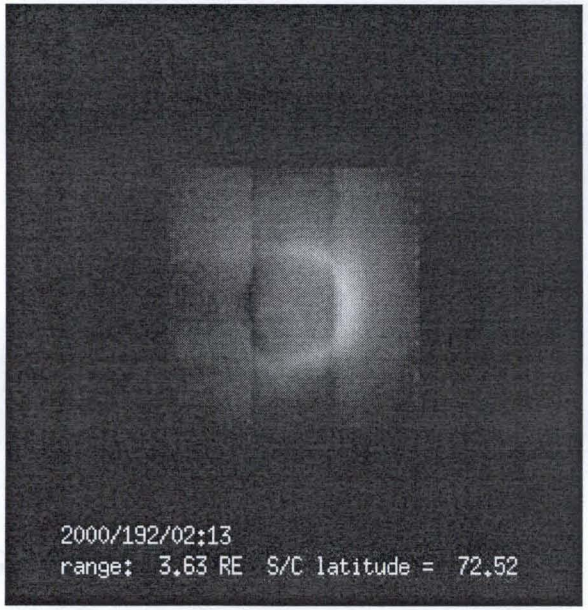
I asked Patrisha about this some time ago, but she must have been in the process of changing jobs. Can you please provide an abstract for this presentation?

Thank you.

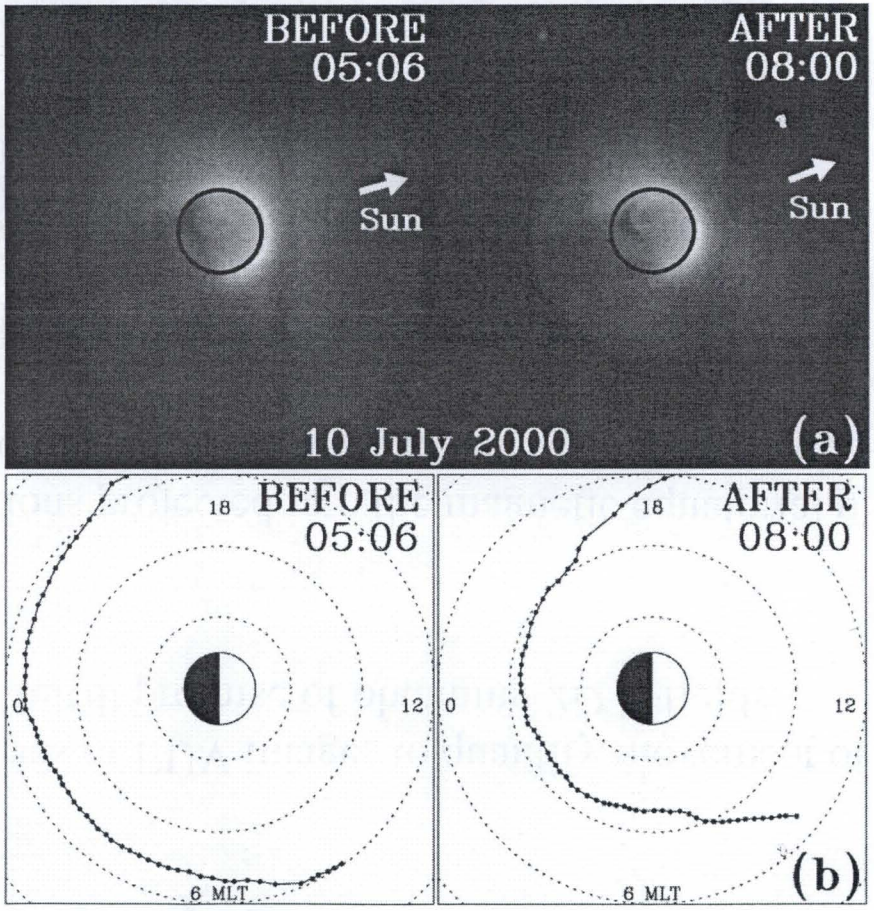
MSFC-515 Presentation

2-D Drift Velocities from the IMAGE EUV Plasmaspheric Imager

D. Gallagher and M. Adrian



Will focus discussion of the technique and initial results on one plasmaspheric erosion time period



Goldstein et al., GRL, 2004

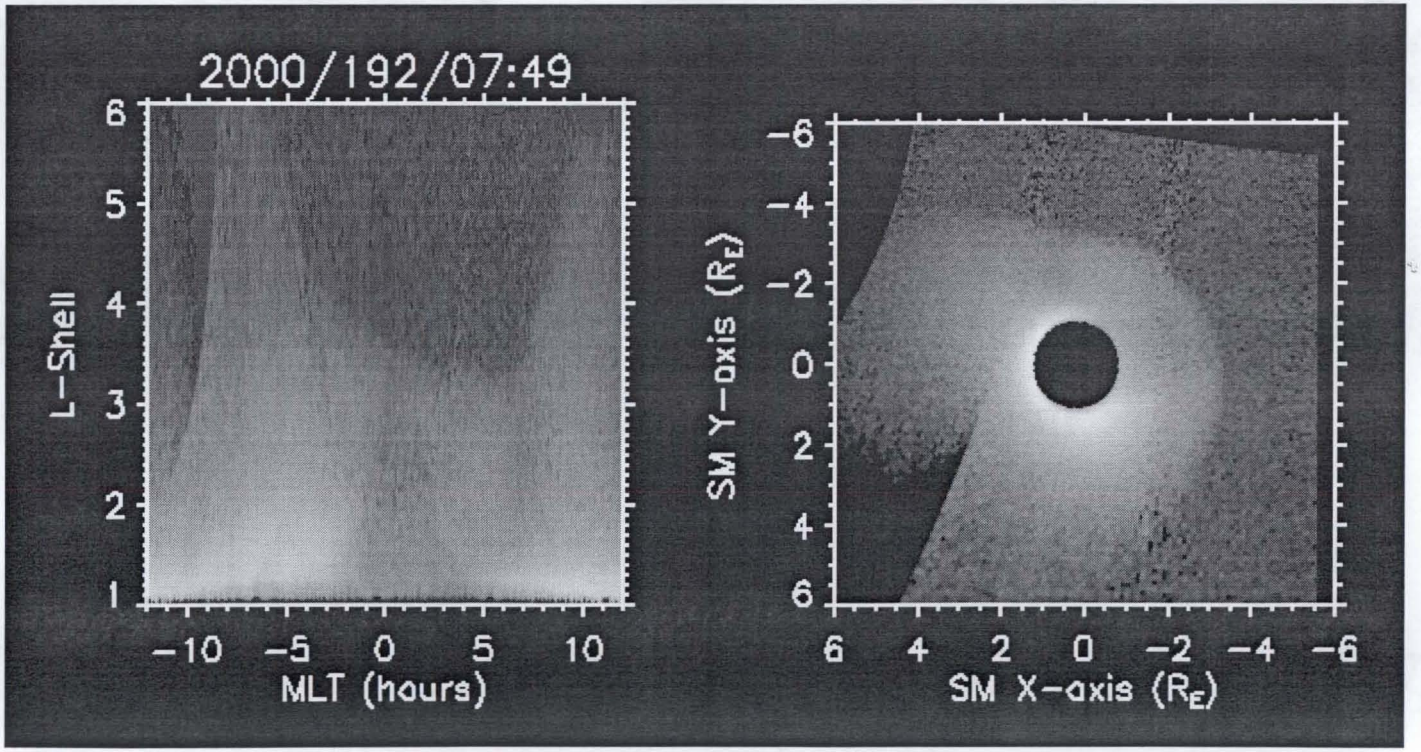
Regional Plasmaspheric Drift

Objective:

Use all available intensity structure in a series of EUV images to quantify movement of image elements within the field of view to fulfill promise of obtaining 2D E-fields.

Preparation:

Perform the analysis using image observations projected into the magnetic equatorial plane such that image products can be directly compared. That is done here using the pseudo-density calculation.



To Compute 2D Plasmaspheric Drift

Techniques: Optical Flow and Cross-Correlation

Optical Flow:

Optical flow constraint equation $$-\frac{\partial I}{\partial t} = \frac{\partial I}{\partial x}\left(\frac{\partial x}{\partial t}\right) + \frac{\partial I}{\partial y}\left(\frac{\partial y}{\partial t}\right)$$

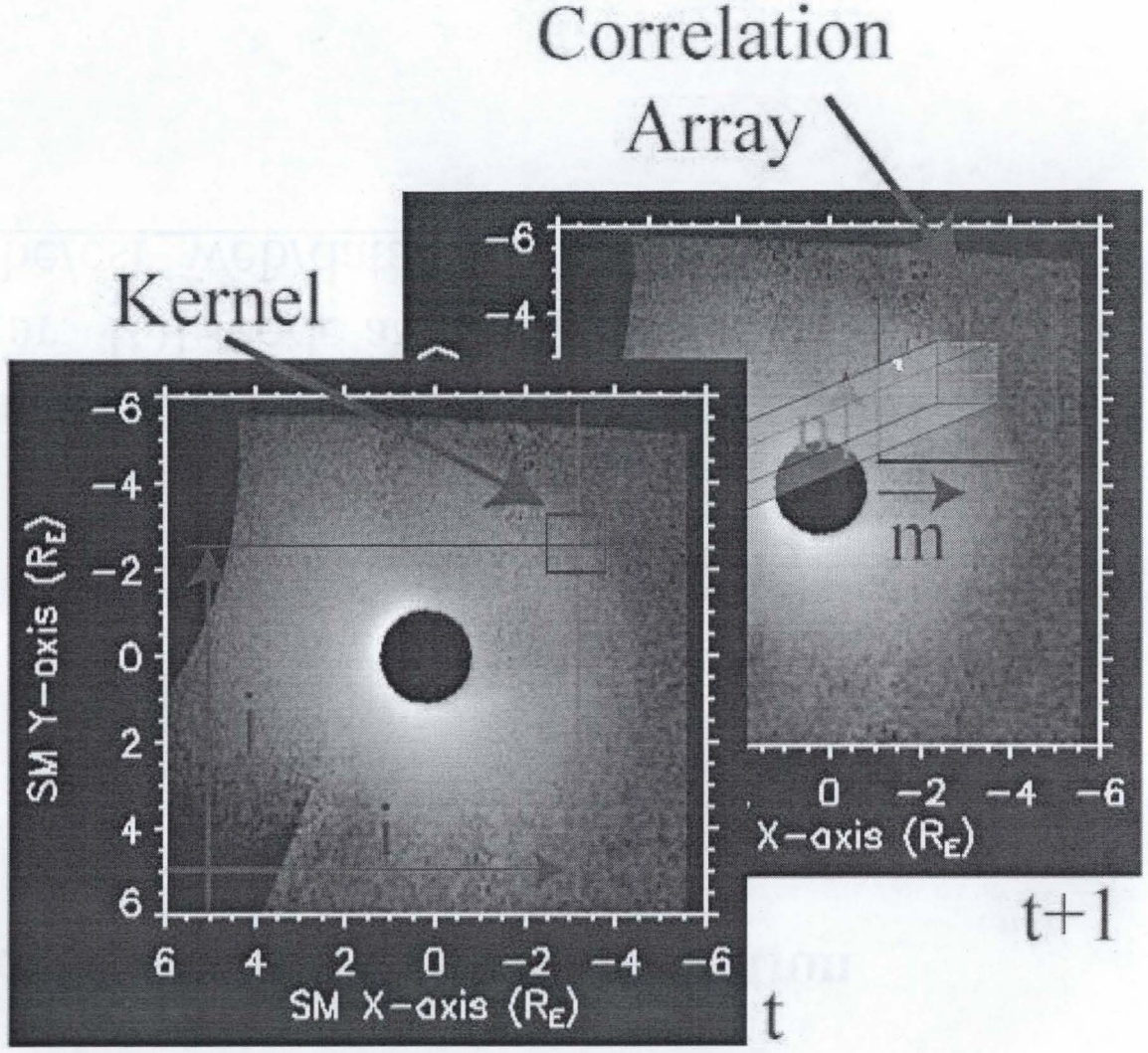
Tried by Christophe Bernard (École Polytechnique in France) without useful results so far. IDL code available at http://csrsrv1.fynu.ucl.ac.be/csr_web/data/

Cross-Correlation:

With this technique image elements are directly compared for correspondence.

Selected elements from one image or kernels are swept across portions of a second image looking for the best match.

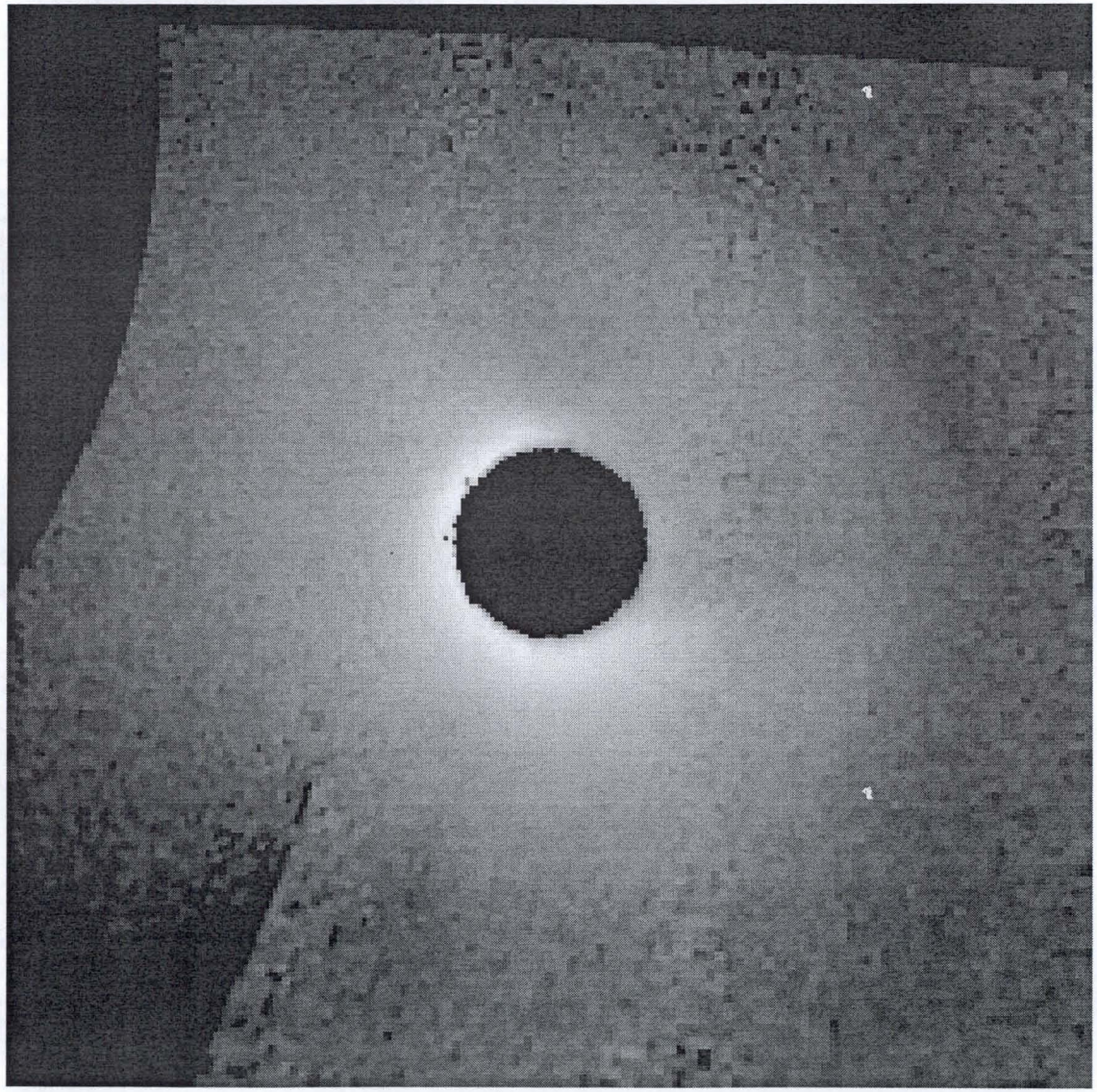
The shifted position of the best match defines the motion of that image element.



$$CrossCorrelationArray(i,j)_{m,n} = \frac{\sum_{kernel@(m,n)} \left((KernalDensity - SubarrayDensity) / KernalDensity \right)^2}{\#elements}$$

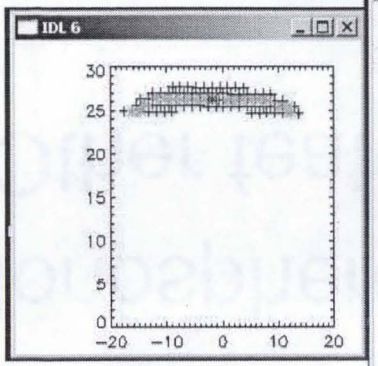
Here's the Challenge

- Plasmapause
- Noise
- Shadow
- Ionosphere
- Other features?



Cross-Correlation Development Tool

Analysis of ridge



Candidate selection criteria

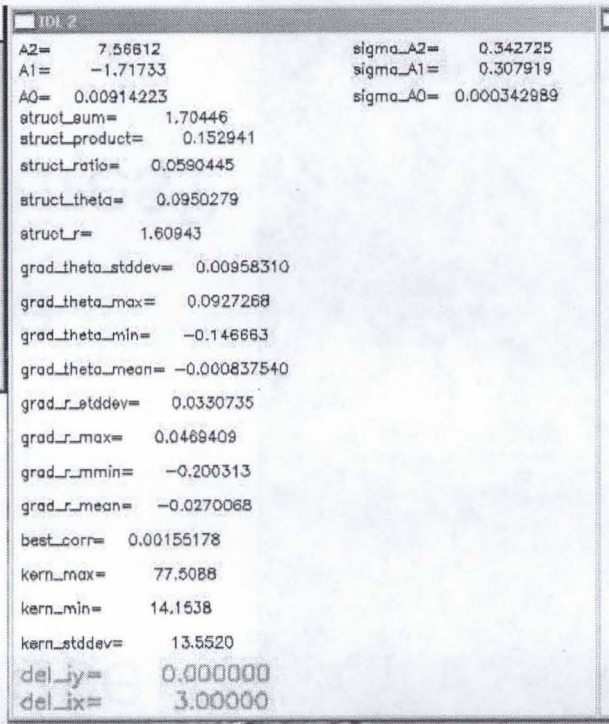
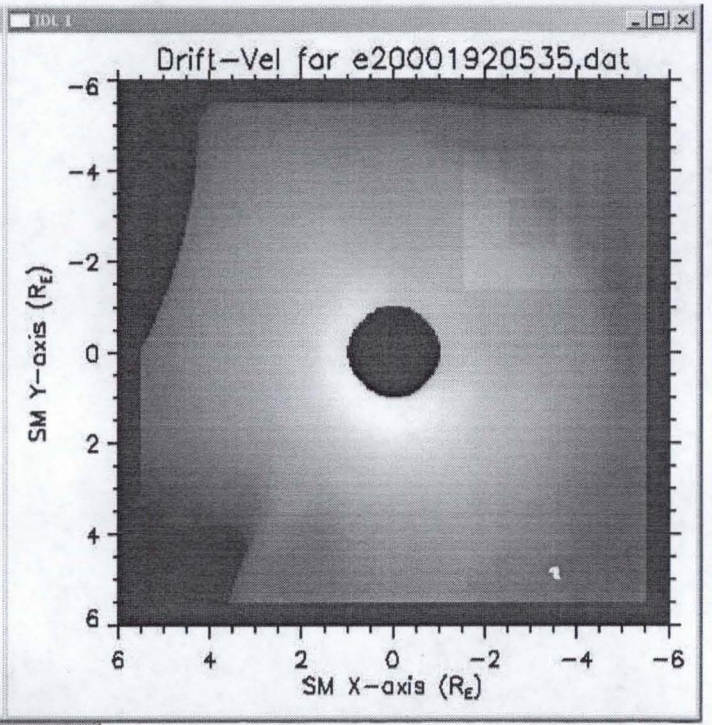
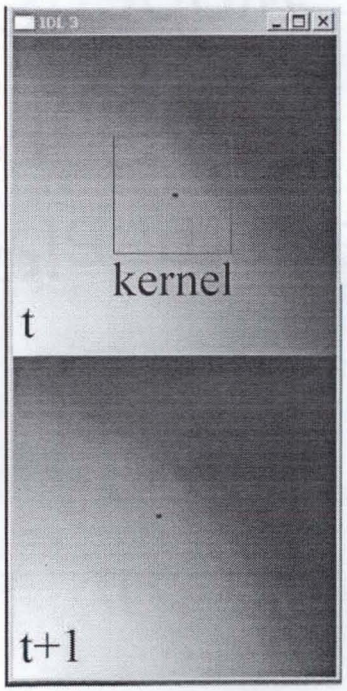
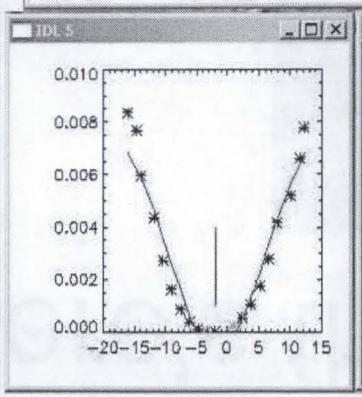


Image for region selection

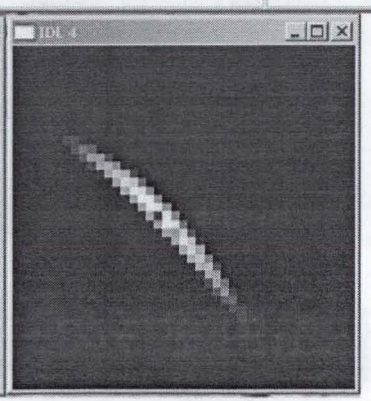


Subarrays being compared





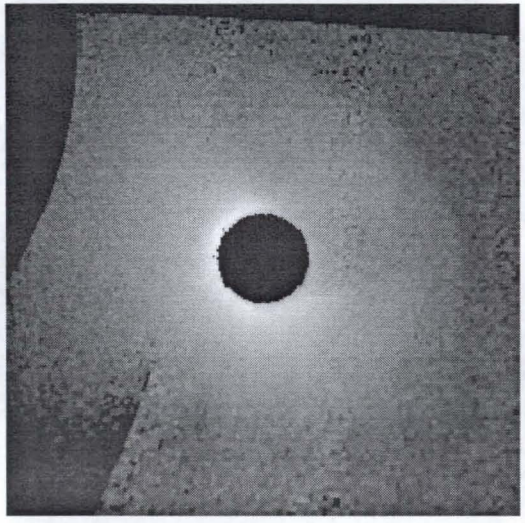
Correlation along ridge



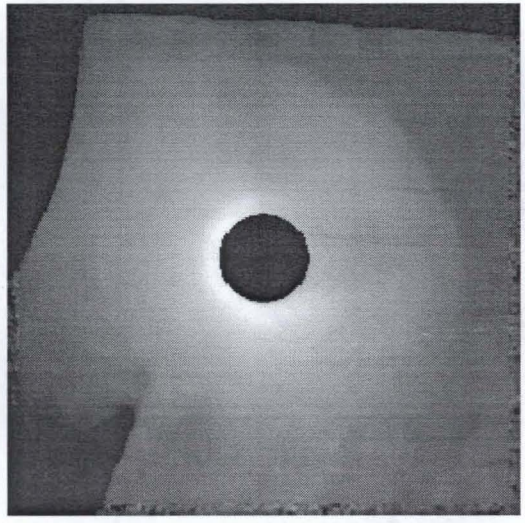
Correlation array

A Few Noise Removal Techniques Tried

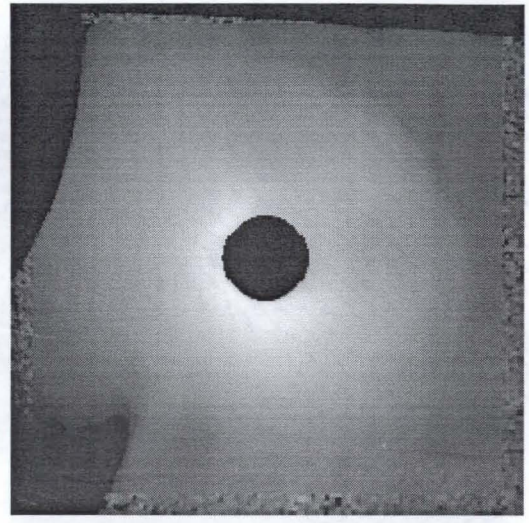
Original



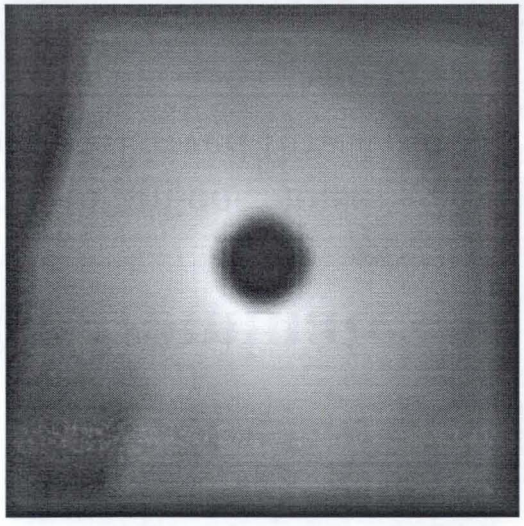
Median - 11



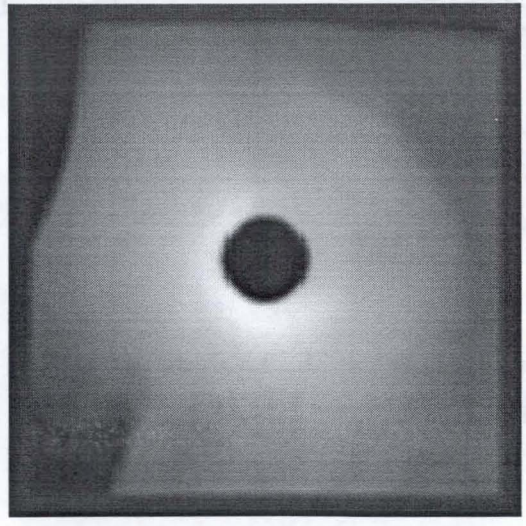
Median - 21



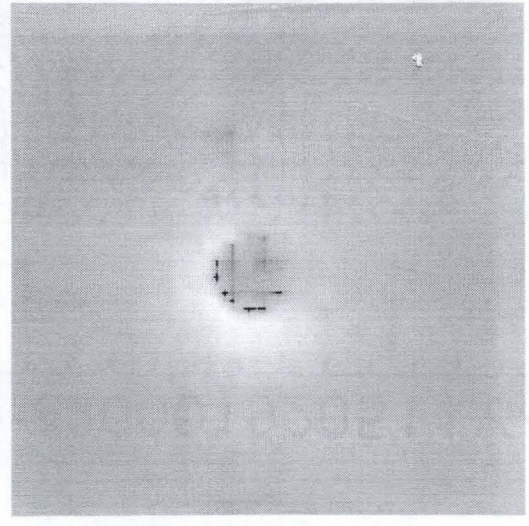
Lee Filter



Box Car Smooth - 5

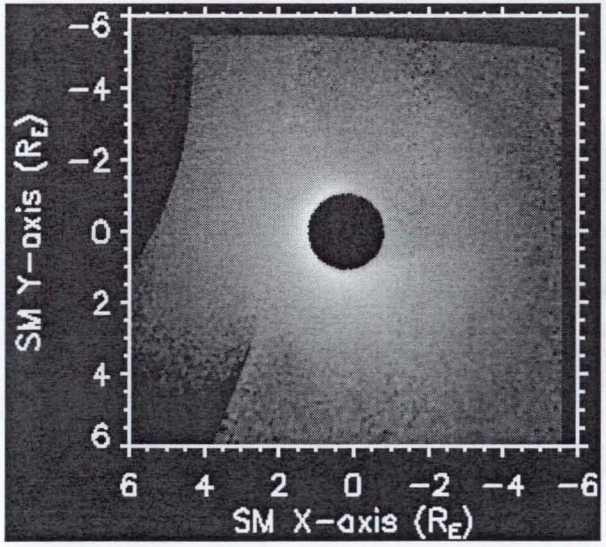


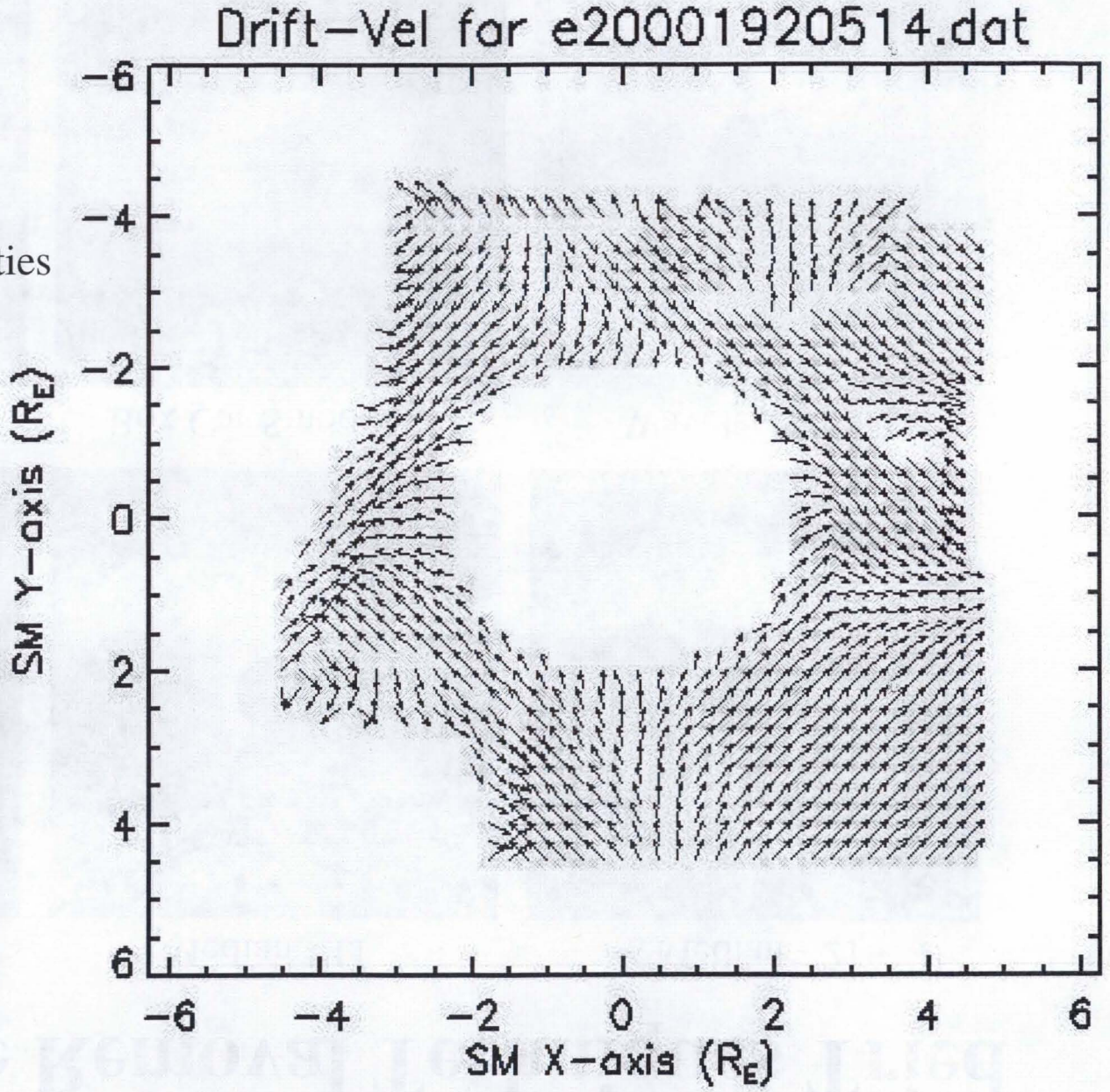
Wavelet Symlet

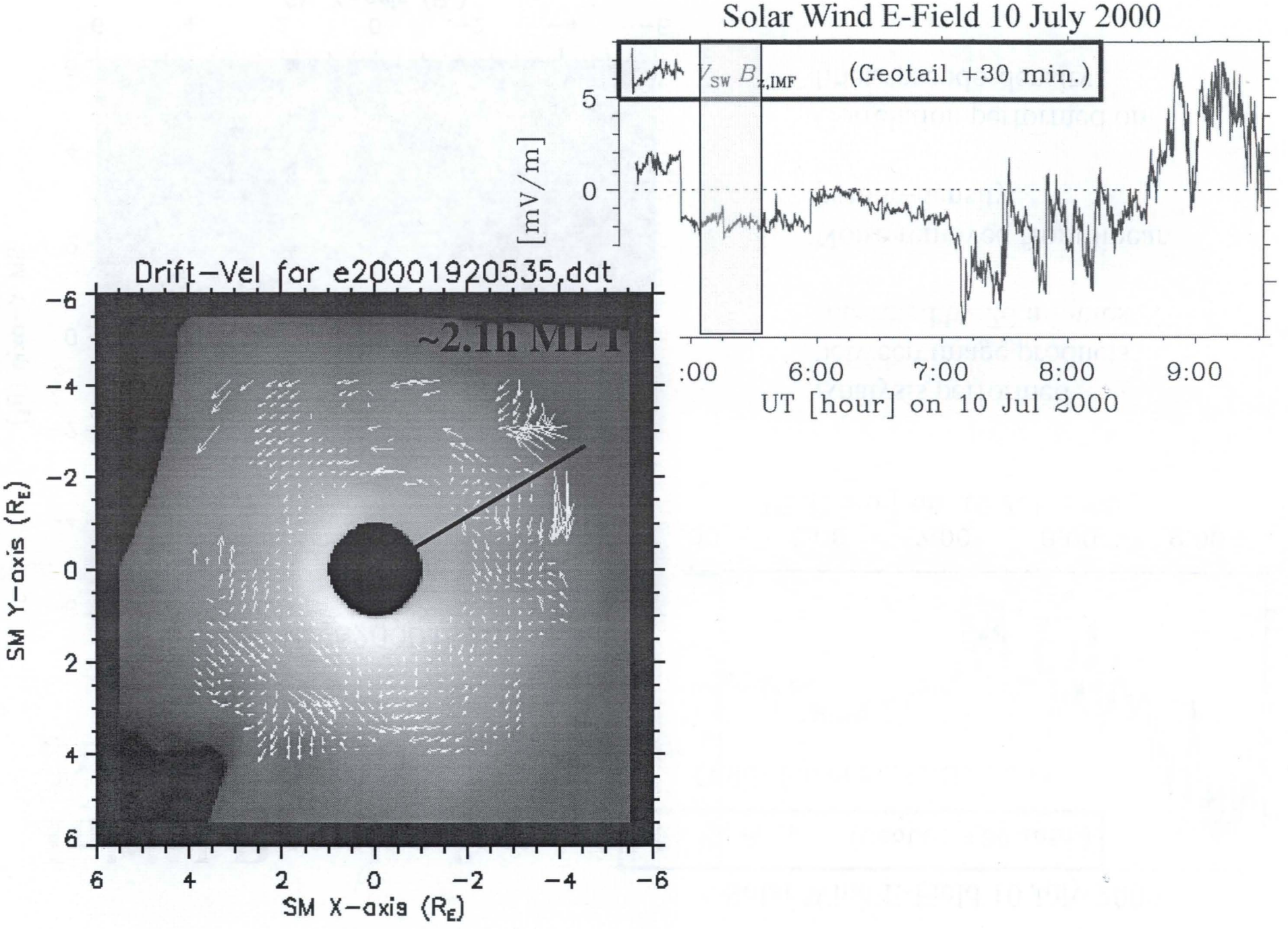


Noise Dominates –

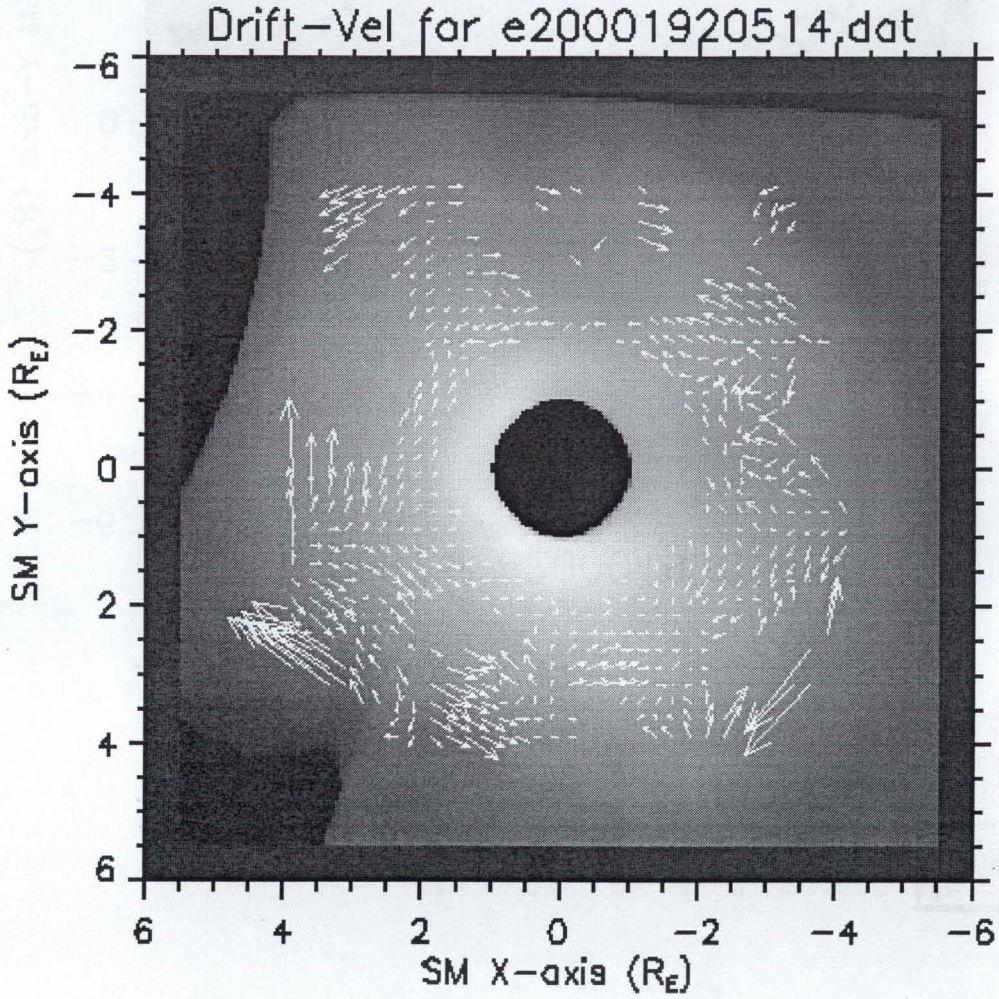
Without treatment, noise dominates derived flow velocities

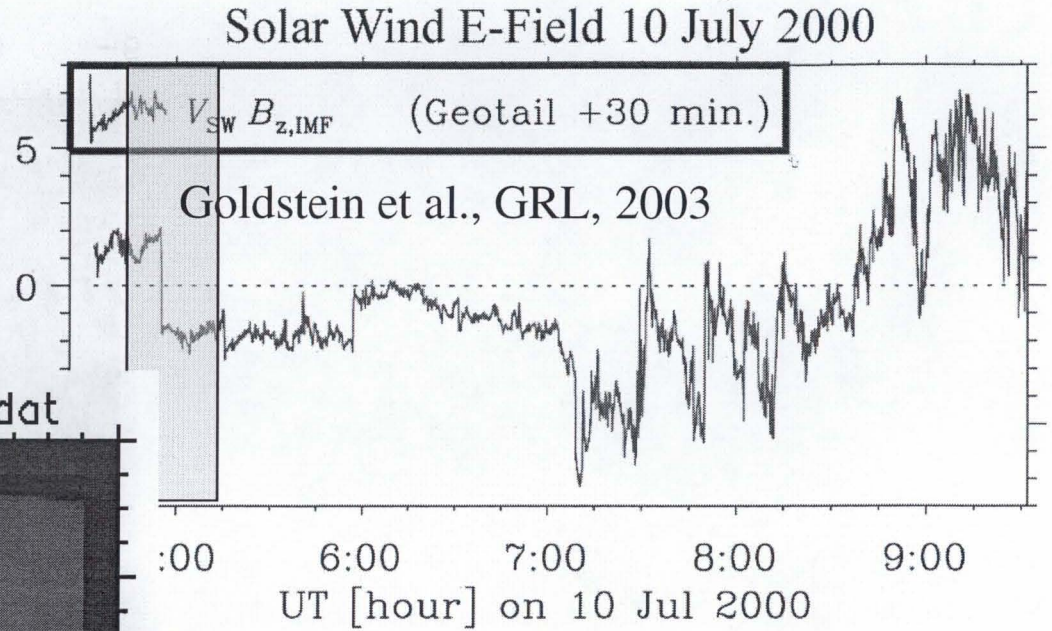





Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
5
0
[mV/m]
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000
Drift-Vel for e20001920535.dat
~2.1h MLT
SM Y-axis (R_E)
SM X-axis (R_E)
6
4
2
0
−2
−4
−6

Initial Results for July 10, 2000

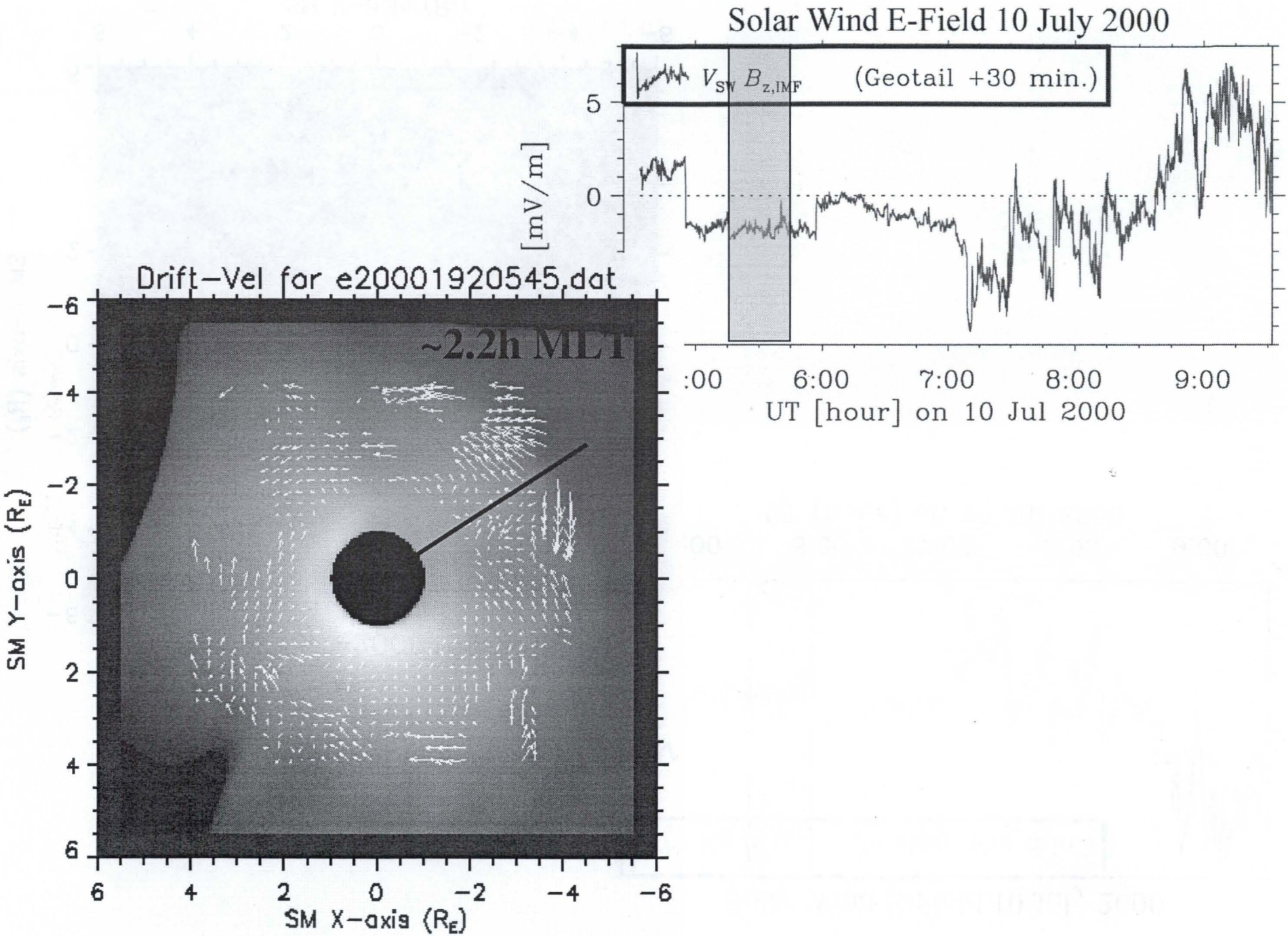


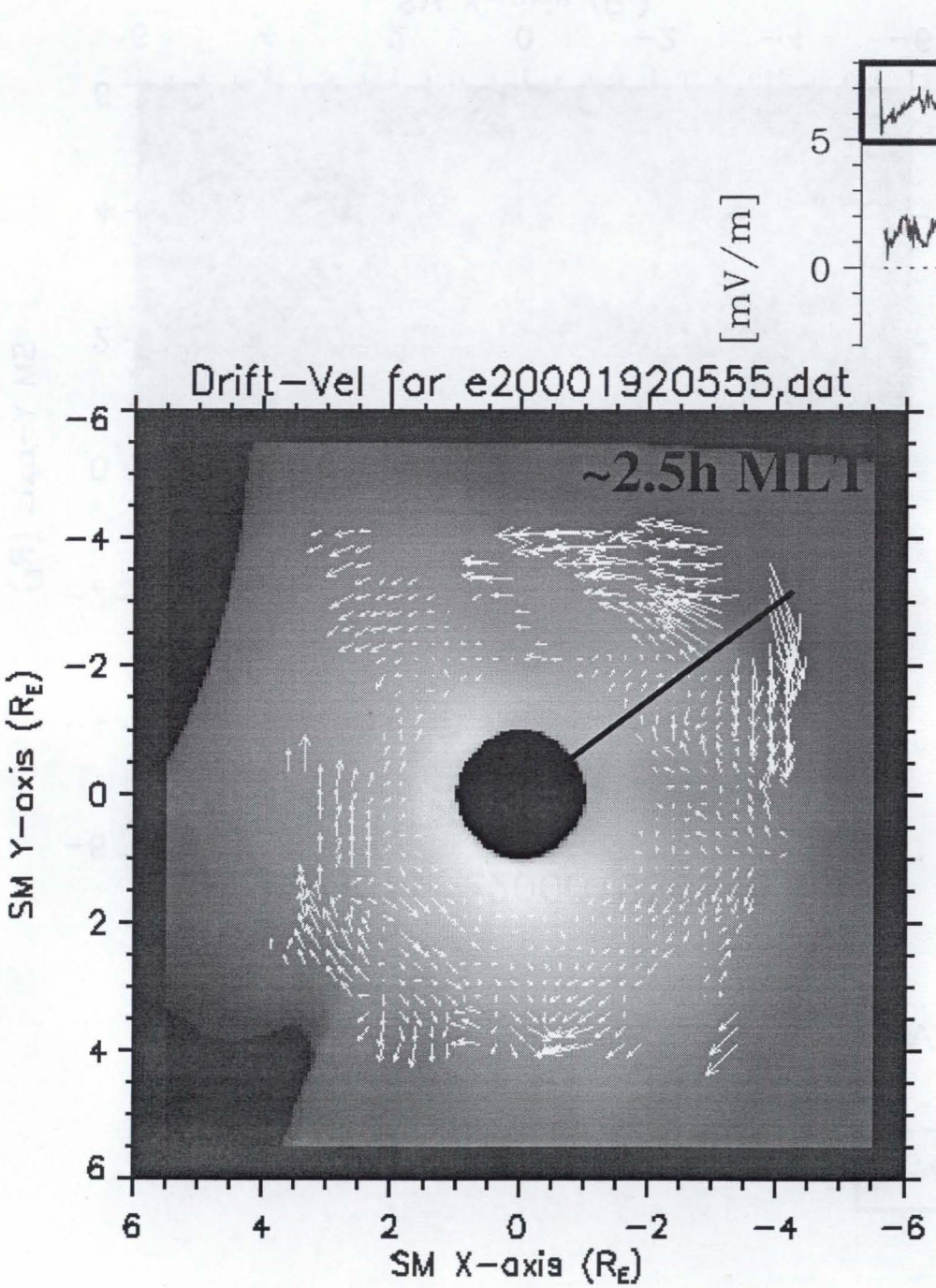


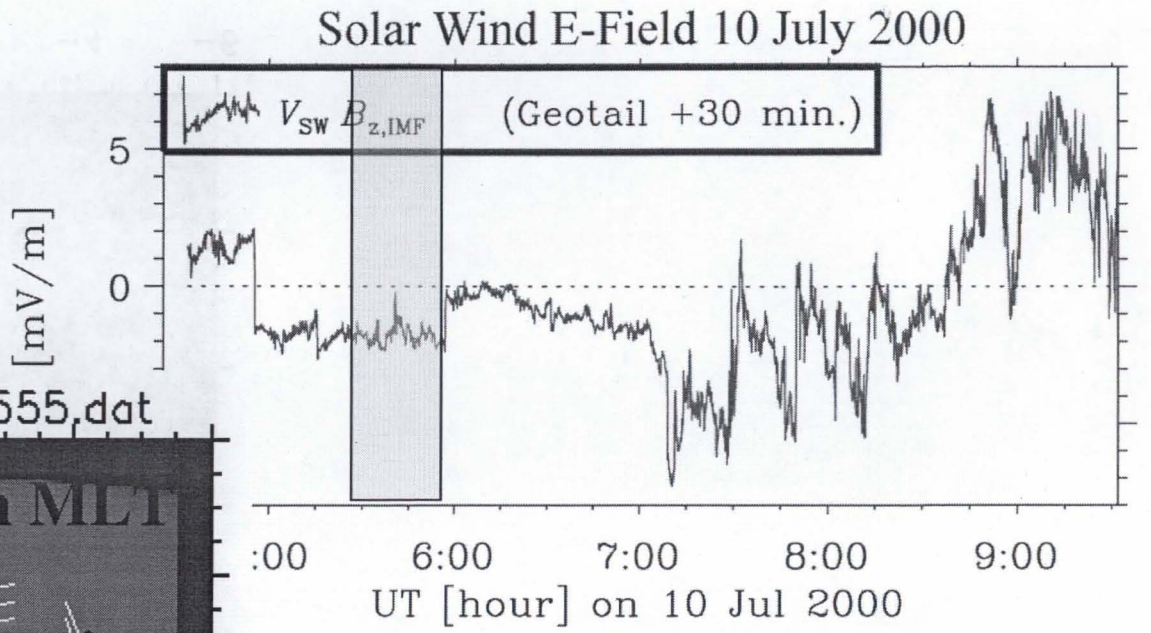
Analysis performed between image products separated by 20 minutes

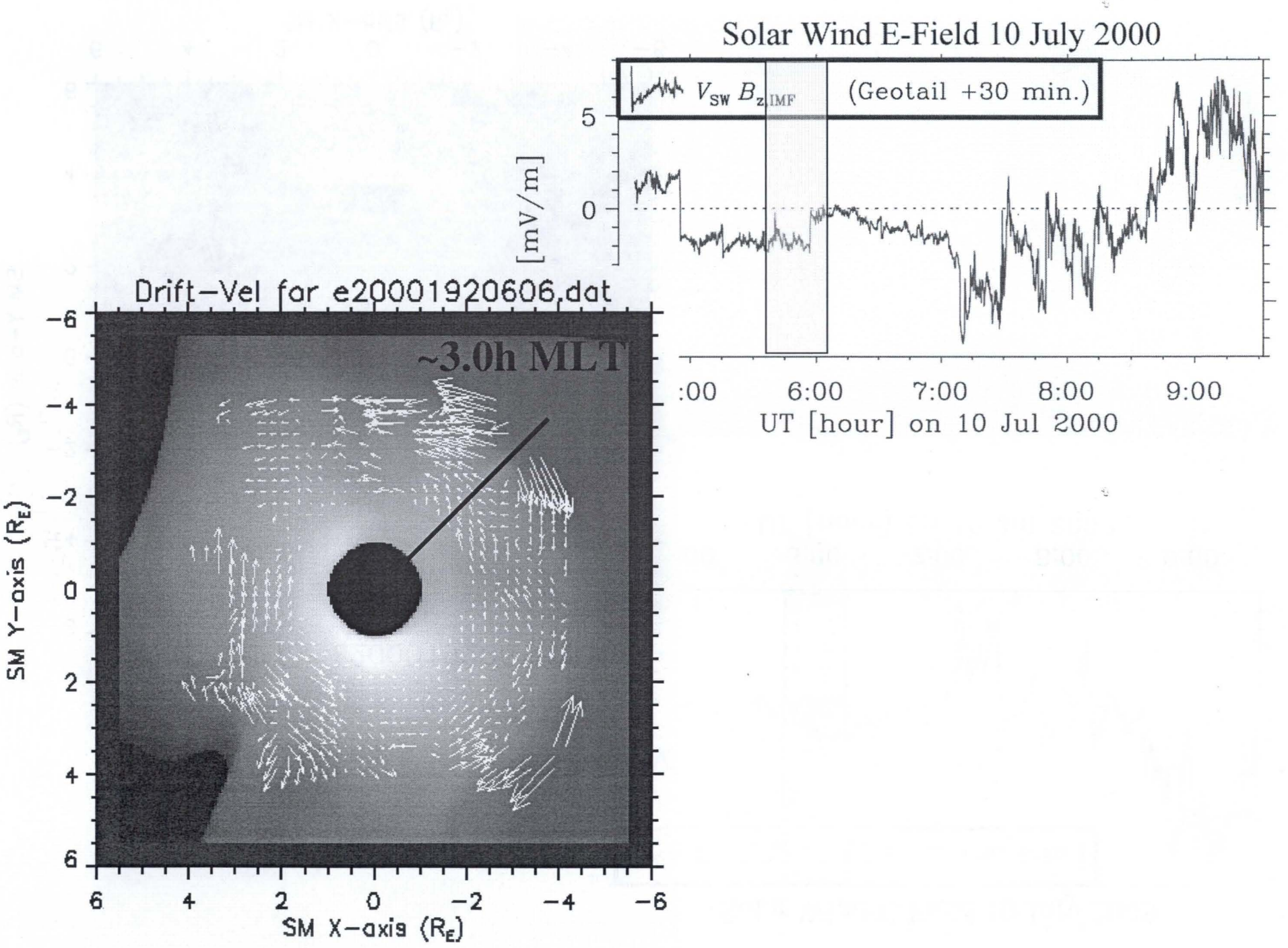
Noise removed from linear pseudo-density.

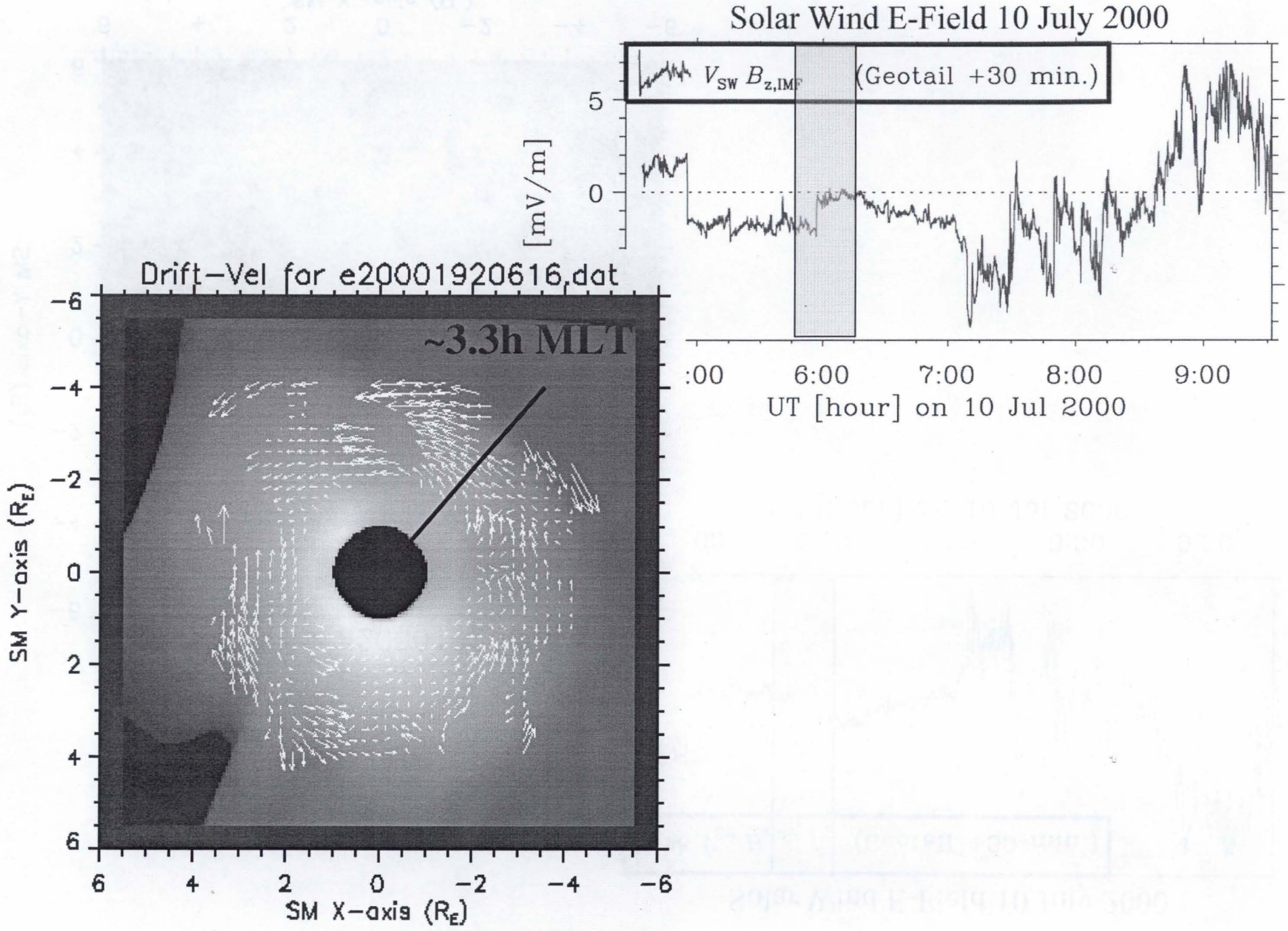
Correlation performed on linear pseudo-density.

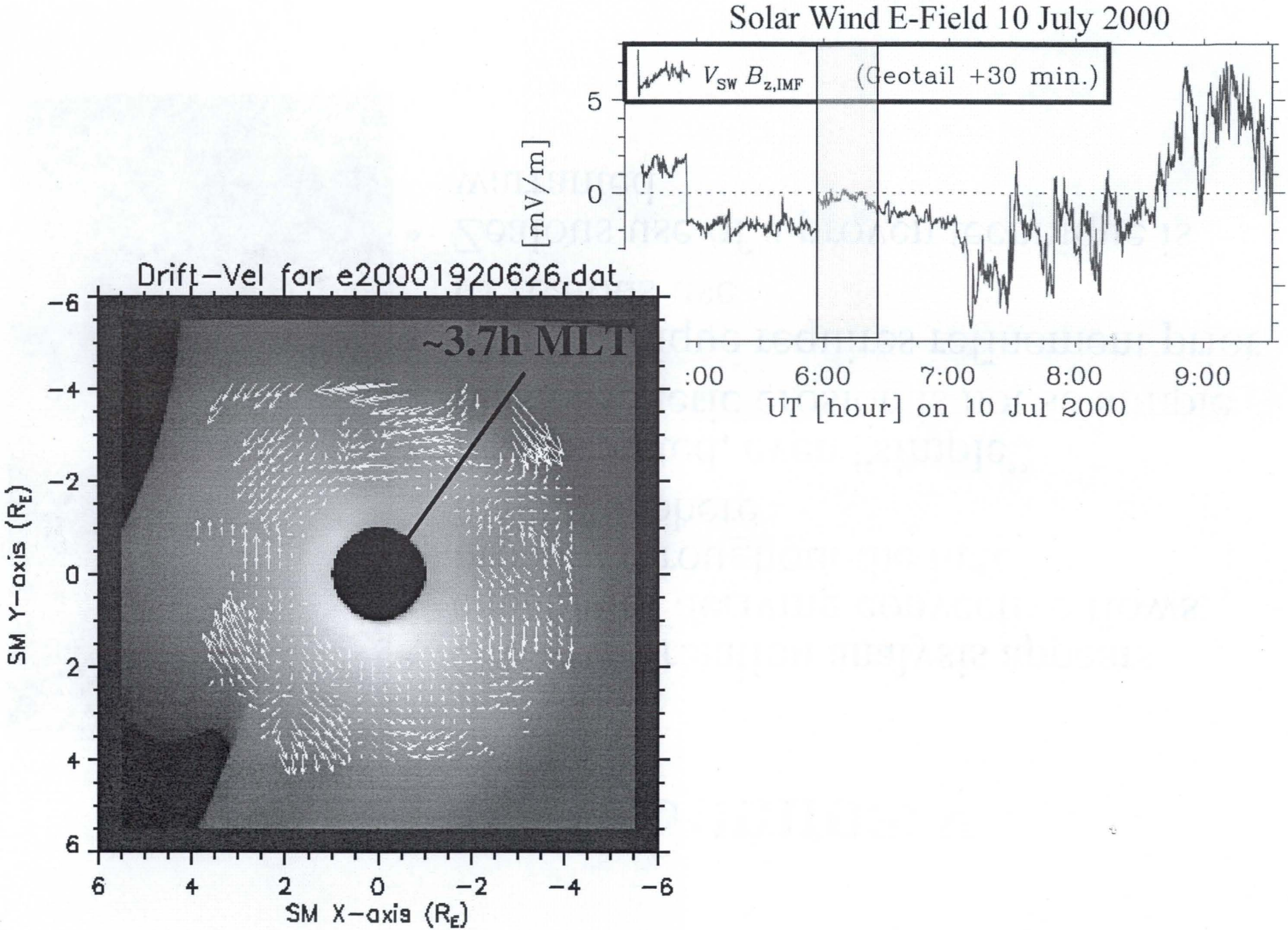

Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
5
0
[mV/m]
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000
Drift−Vel for e20001920545.dat
~2.2h MLT
−6
−4
−2
0
2
4
6
SM Y−axis (R_E)
6
4
2
0
−2
−4
−6
SM X−axis (R_E)


Drift−Vel for e20001920555.dat
~2.5h MLT
SM Y−axis (R_E)
SM X−axis (R_E)
6
4
2
0
−2
−4
−6

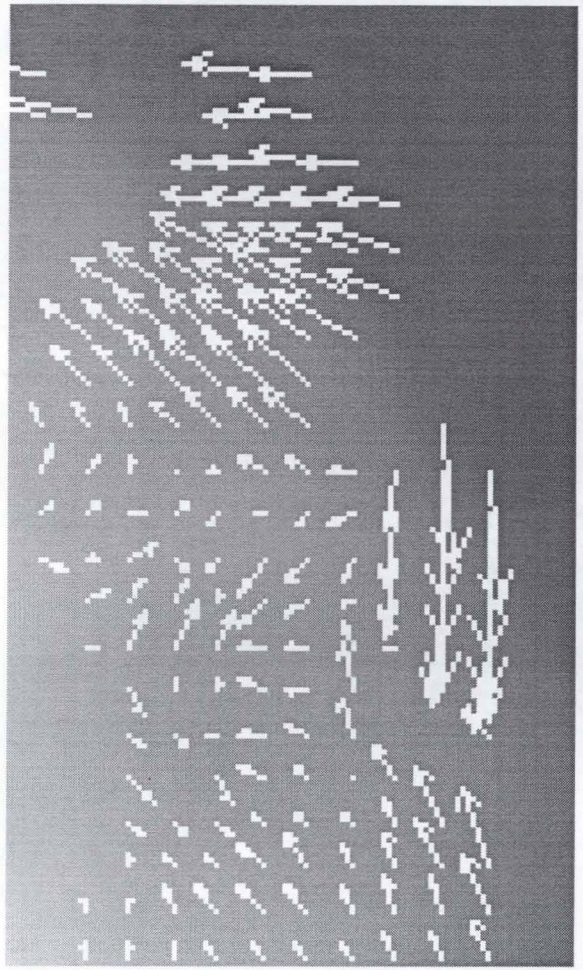

Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
[mV/m]
5
0
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000


Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
5
0
[mV/m]
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000
Drift-Vel for e20001920606.dat
~3.0h MLT
SM Y-axis (R_E)
SM X-axis (R_E)
6
4
2
0
−2
−4
−6


Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
5
0
[mV/m]
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000
Drift-Vel for e20001920616.dat
~3.3h MLT
SM Y-axis (R_E)
SM X-axis (R_E)
6
4
2
0
-2
-4
-6


Solar Wind E-Field 10 July 2000
V_{SW} $B_{z,IMF}$
(Geotail +30 min.)
5
0
[mV/m]
:00
6:00
7:00
8:00
9:00
UT [hour] on 10 Jul 2000
Drift-Vel for e20001920626.dat
~3.7h MLT
SM Y-axis (R_E)
SM X-axis (R_E)
6
4
2
0
-2
-4
-6

Summary



- Cross-Correlation analysis appears capable of deriving convective flows broadly throughout the inner magnetosphere
- As suspected, even “simple” plasmaspheric erosion is not so simple
- The technique requires refinement prior to zealous use
- Zealous use of a proven technique is warranted