

Solar Explosion Produces Ionospheric Mass Ejection



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- 1968 text book wisdom:
 - Solar flare particles enter ionosphere, create aurora
 - Mass and energy are gained by the earth.

- 1998 wisdom:
 - Solar wind blast compresses magnetosphere, heats ionosphere, ejects hot gas.
 - Energy is gained, but mass is lost from earth.

What Happened?



- ISTP spacecraft now track solar disturbances to earth.
 - Solar explosions produce *intense, gusty solar wind*.
 - Arrival is heralded by *a sonic boom*. (MHD Shock Wave).
- Shock squeezes the magnetosphere and “tells” it that the blast has arrived at the outer boundary.
 - Energizes plasma throughout magnetosphere
 - Dayside ionosphere is “cooked” by energy from the shock and solar wind.
- Mass outflow increases more than 10-fold.
 - Magnetosphere fills with geogenic plasma as magnetospheric storm ensues.

Coronal Mass Ejection Drives Ionospheric Mass Ejection

24-25 Sept. 1998

1. Shock incident on magnetosphere

2. Shock propagates through polar wind plasma, heating and accelerating it

3. Hot accelerated plasma cloud supplied to magnetotail

4. Shock propagates along magnetic field into ionosphere

5. Plasma heating causes ionospheric mass ejection

6. Followed by dense cold cloud of plasma supplied to magnetotail



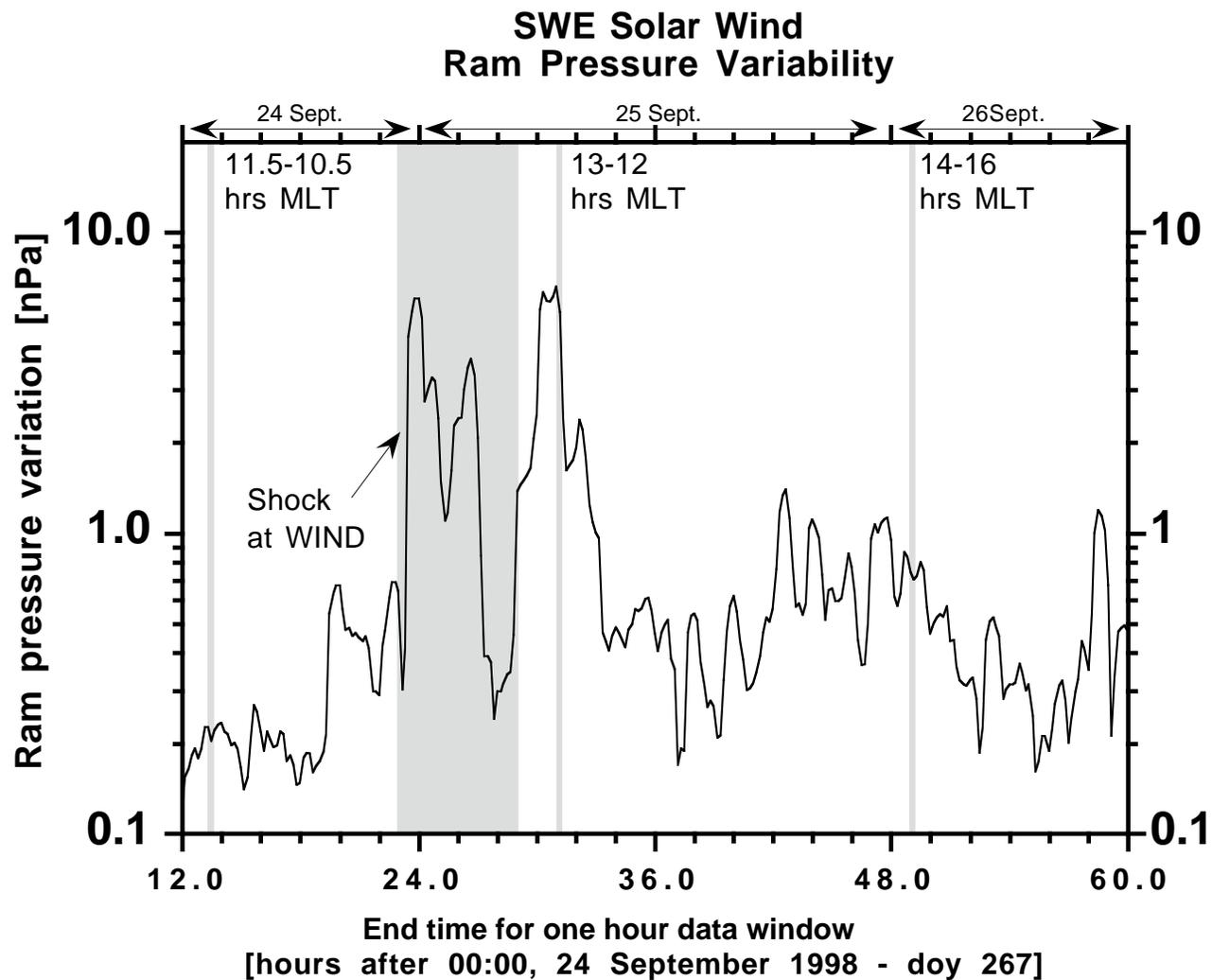
Hypotheses

- Mass flux of the polar plasma fountain increases in response to solar wind dynamic (ram) pressure or its variability.
- Greater mass flux to the magnetotail contributes to the development of magnetospheric plasma storms.

Observations



- Gusty Solar Wind 185 Earth Radii Upstream:

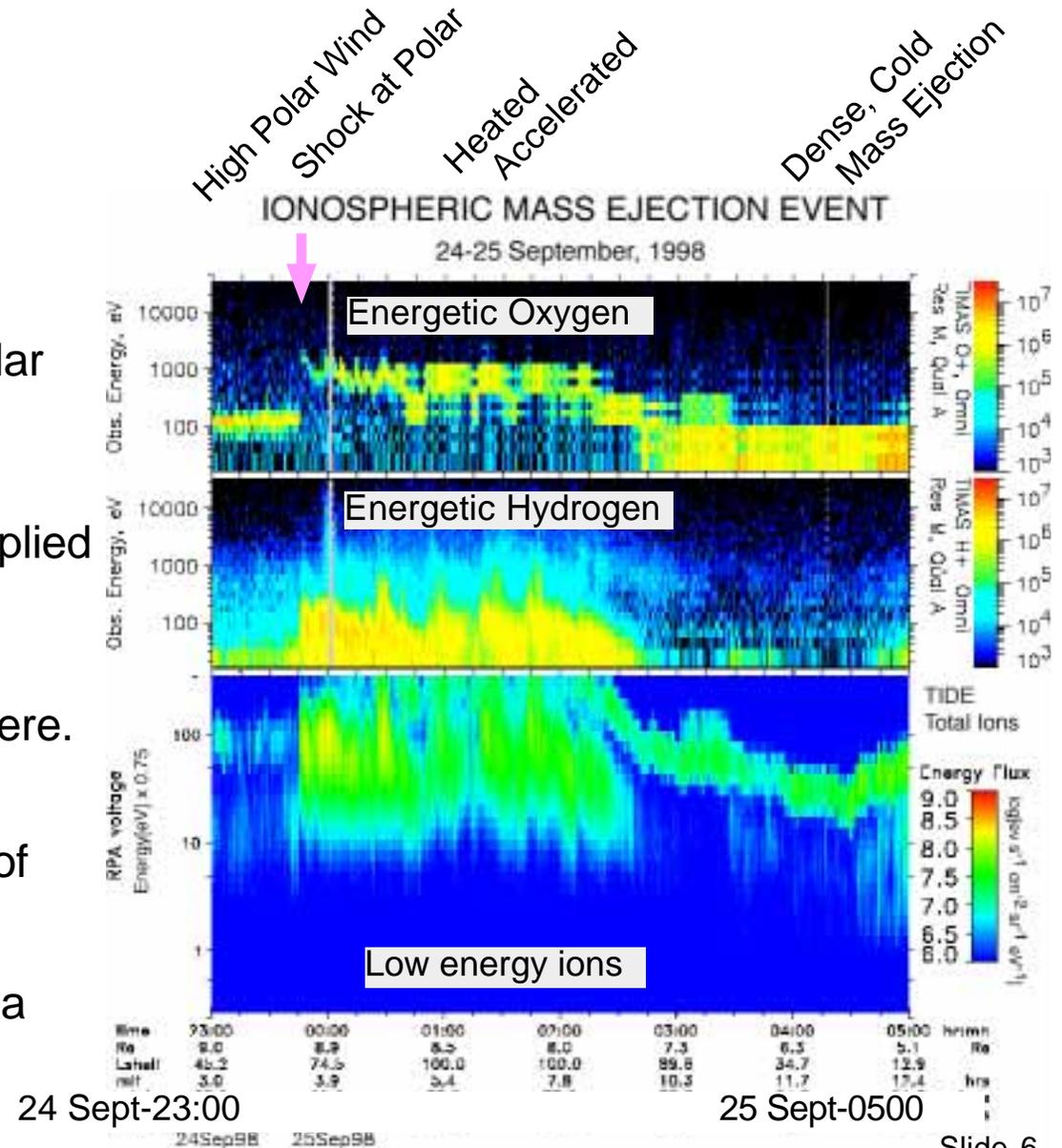


Observations



- High Altitude Polar Plasma outflows

1. Shock incident on magnetosphere.
2. Propagates through the polar wind plasma, heating and accelerating.
3. Fast, hot plasma cloud supplied to magnetotail.
4. Shock propagates along magnetic field into ionosphere.
5. Plasma heating causes ionospheric mass ejection of cold dense O^+ .
6. Cold, dense cloud of plasma supplied to magnetotail.

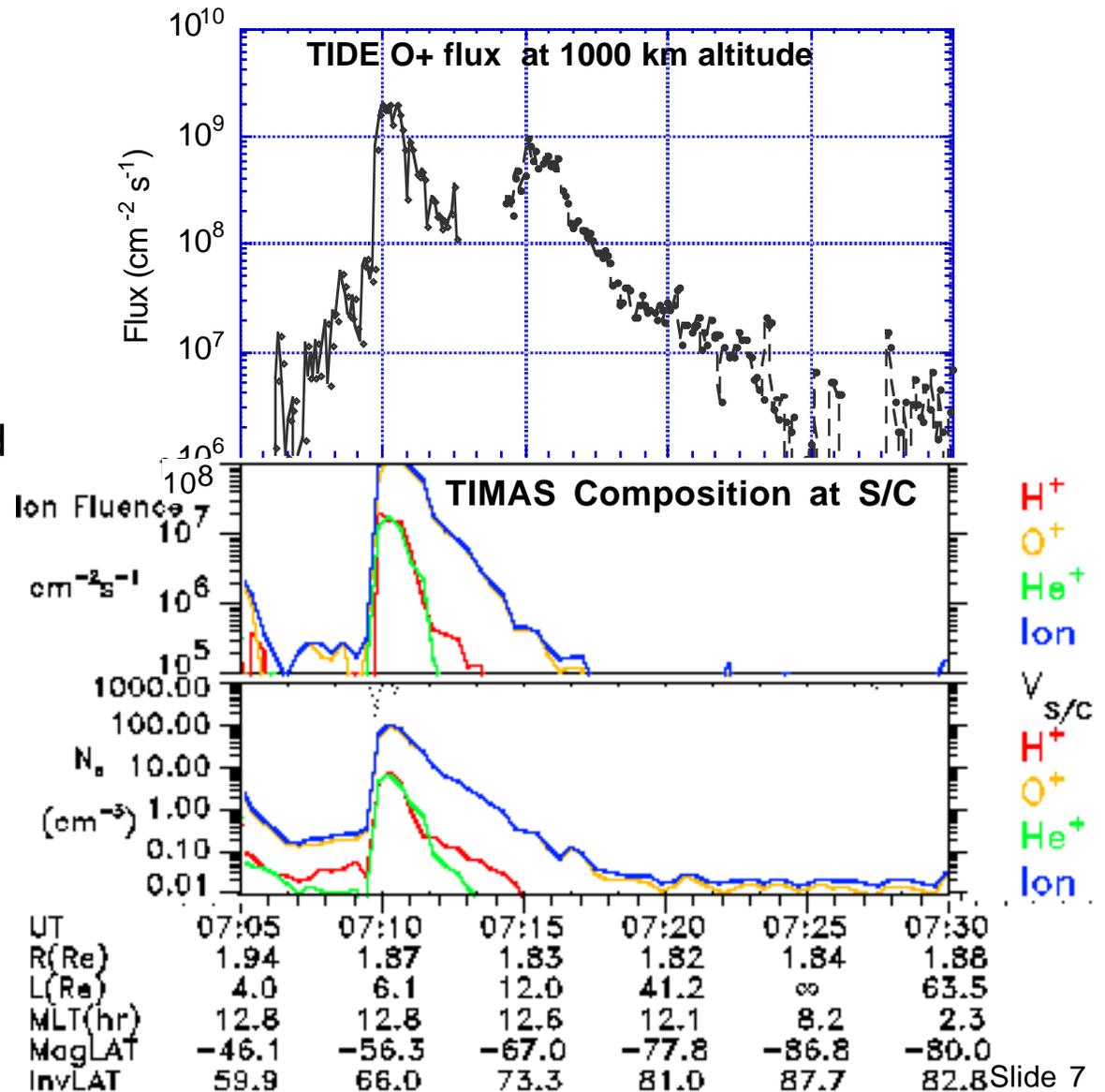




Observations

• Fountain Source

- At lower altitudes about 1 Re above the ionosphere
- Large enhancement of cold O⁺ outflow observed during event.
- Compared with earlier and later passes through fountain source:
 - Much greater flux
 - Oxygen dominates Hydrogen
 - Much higher density
 - Lower temperature

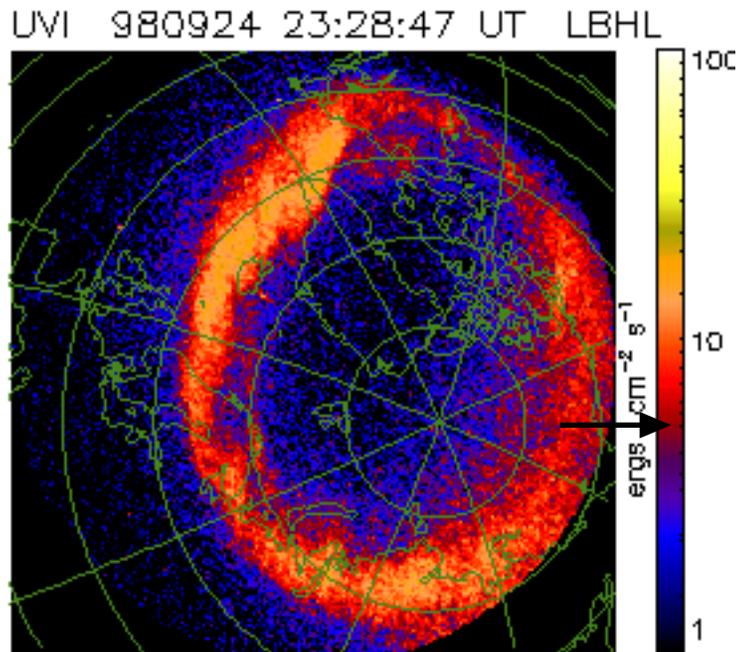


Observations



- Auroral brightening reflects ionospheric heating:

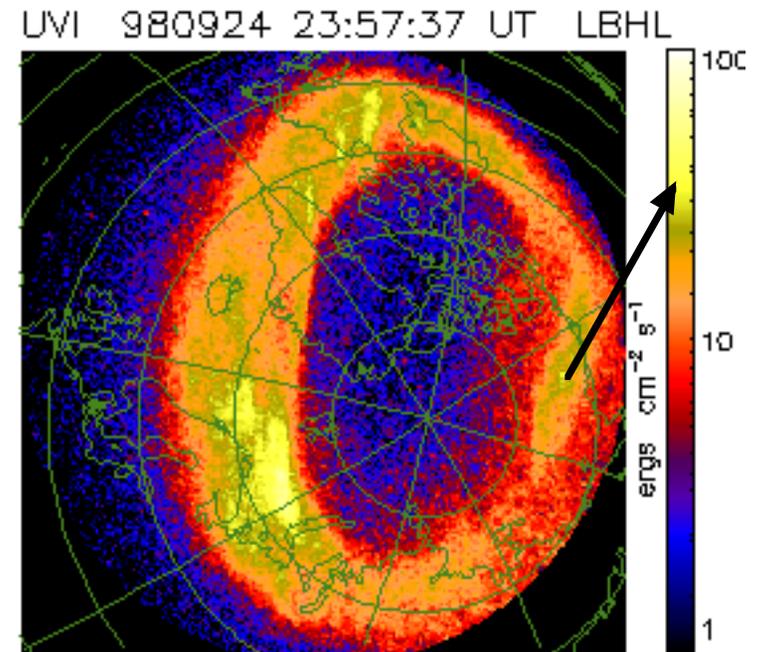
Before
23:30
night day



T.E.Moore/FM98/IME

Shock
23:40 UT

After
24:00
night day



Slide 8

Conclusions



- Ionospheric mass ejected as direct response to intense solar wind.
- Two-stage response:
 - 1. shock acceleration of prior outflow.
 - 2. Enhanced outflow mass.
- Strong variation of plasma supply to magnetotail.
 - Magnetospheric storm influence likely.
- Outflow mass currently in rough balance with dust accretion.
 - Long term compositional effects possible.
 - Little net loss at present solar activity levels.

Next Steps



- Survey of CME events in solar wind.
- Tracking events through solar maximum in 2001.
- Assessment of plasma supply to magnetotail and storms using global circulation models.
- Initial efforts reported in afternoon session: SM22B, by, e.g.:
 - Observ.: 01-Chappell et al., 02-Giles et al.
 - Models: 05-White et al., and 09-Winglee