Interaction Between Penetration and Disturbance Dynamo Electric Fields

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Outline:

1st case: March 31 2001 storm, using CTIPe & RCM E-field

2nd case: April 17 2002 Storm—Comparison with the Jicamarca observation

Investigation of impact of storm-time conductivity on penetration E-field
What is the source of the Storm-time electric fields?

2 Processes:
-- Prompt Penetration [e.g., Jaggi and Wolf, 1973]
-- Disturbance dynamo [e.g., Blanc and Richmond, 1980]

[Scherliess and Fejer, 1997]

? Do the two sources interact with each other??
Purpose of this Study

What is the source of disturbed electric field?

- Do the two sources interact with each other?
- What are the time scales of ionospheric electric field disturbances at middle and low latitudes due to the two sources?
- What is their relative importance in disturbed electric fields?
- What is their importance in restructuring the low latitude thermosphere and ionosphere?

Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics (CTIPe) model is used.
CTIPe: 2 High Latitude Drivers

TIROS/NOAA Auroral precipitation patterns driven by power index:

- Update forcing every 12 minutes
- **DISTURBANCE DYNAMO** solved self-consistently

Weimer electric field patterns driven by solar wind data:

- IMF $B_x = -1.9$ nT $B_y = -7.9$ nT SW Vel = 350.0 km/sec
Rice Convection Model (RCM)

RCM Input:

--polar cap potential drop
--Tsyganenko 2003 storm magnetic field
--plasma sheet density and temperature on the high-latitude boundary

Penetration Electric fields

CTIPe Input

[Image of graph showing Dst, IMF Bz, and another graph with fields labeled with times and dates]

[Sazykin et al., 2005]
Response of Vertical ExB Drift

4 CTIPe Runs:

-----: Quiet time
___: Disturbance Dynamo only (Weimer)
___: Penetration only (RCM)
___: both Disturbance Dynamo (Weimer) & Penetration (RCM)

-- Very Dynamic!
-- Very Complicated!
-- Hard to distinguish two effects!
DAYSIDE
Changes from Quiet Time

___: Disturbance Dynamo only
___: Penetration only
___: both Disturbance Dynamo & Penetration

Early stage of the storm:

★ Dayside:
---Penetration effect is dominant
Nightside Changes from Quiet Time

___: Disturbance Dynamo only
___: Penetration only
___: both Disturbance Dynamo & Penetration

Both penetration and disturbance dynamo effects are comparable.

Relative importance depends on Storm-time.
Why the Disturbance dynamo is modified preferentially at night?

**Quiet-time**

Ionospheric dynamo:
- Day: E-region
- Night: F-region

**STORM TIME**

Penetration electric field

Disturbance dynamo

Changes in the F-region
- Conductivity
- Neutral winds
April 17 2002

Run 1: Time dependent plasmasheet density ($N_{ps}$) and temperature ($T_{ps}$) (dash)

Run 2: Constant $N_{ps}$ and $T_{ps}$, $F107=190$ (solid)

Run 3: Same as Run 2 but for lower conductivity ($F107=100$)

Run 4: Same as Run 2 but $N_{ps} \times 3$, $T_{ps}/3$, keeping $PV^{\gamma}$ constant

Run 5: Same as Run 2 but increased $N_{ps}$ and $T_{ps}$ by a factor of $\sqrt{3}$.
Jicamarca Observation
Storm-time Coupling

RCM Penetration

Conductivity Change

Disturbance Dynamo

Neutral Wind Change

Ionosphere/Plasmasphere Redistribution

CTIPe

Ion-drag Change
Impact of Storm-time Conductivity on Penetration Electric Field

CTIPe conductivity (Mar 31 2001)

RCM potential solver
Change in the polar cap potential is important in generating the penetration E-field.
DIFFERENCE at 6.3UT:
\( \Sigma \text{STORM} - \Sigma \text{QUIET} \) RCM runs

- dif-EPot
- dif-\( E_{\text{EAST}} \)
- dif-\( E_{\text{Equat}} \)
- dif-FAC

Combined effects of Aurora conductivity (high latitude) & Storm-time conductivity (mid-/low-latitudes)

\( \rightarrow \) \( \Sigma \) Ped reduction in sub-auroral latitude.
SAIDs Conductance from CTIPe

$\Rightarrow$ change in $\Sigma$PED/$\Sigma$HALL ratio

WITH SAIDs

WITHOUT SAIDs

$V_{\text{EAST}} \ [\text{m/s}]$

$\Sigma p$

$\Sigma H$

$\text{Ne} \ [\text{cm}^{-3}]$

$\text{Ti} \ [\text{K}]$

50° mLAT

70° mLAT
The effect of the storm-time conductivity on the electric field will require further investigation.
Conclusions

March 2001 Storm run was studied in order to investigate the relative contributions of the penetration and disturbance dynamo electric fields, and their interactions.

→ Daytime:
  Sudden increase in the polar cap potential drop generates the increase in the eastward electric field.
  Penetration effect dominant in the early stage of the storm.

→ Nighttime:
  Comparable penetration and disturbance dynamo effects.
  Large impact of the penetration on disturbance dynamo:
    → Changes in conductivity and winds in the F-region caused by penetration modify disturbance dynamo.

Good Agreement for April 17, 2002 storm with the Jicamarca observation.

The effect of the storm-time conductivity on the electric field will require further investigation.