



Introduction

Equatorial Spread F (ESF) is the name given to a broad spectrum of plasma irregularities observed in the low latitude F-region. Large-scale depletions associated with ESF can be observed with all-sky imagers (ASI) with a 6300 Å filter. We use an ASI in Argentina (31.8° S, 69.3° W, 19.8° S mag lat) and another in Colombia (5.6° N, 73.52°, 16.4° N mag lat) that is located close to the magnetic conjugate point of the Argentina ASI. Figure 1 shows images from these two ASIs on a map of South America with a third image from the Jicamarca Radio Observatory. We expect that that airglow structures associated with ESF should be observed concurrently at both sites since the overall process is flux-tube integrated (Mendillo *et al.*, 2005). These large-scale depletions are known to be associated with medium-scale irregularities that can be detected using ground-based receivers and the GPS network (Ledvina and Makela, 2005).

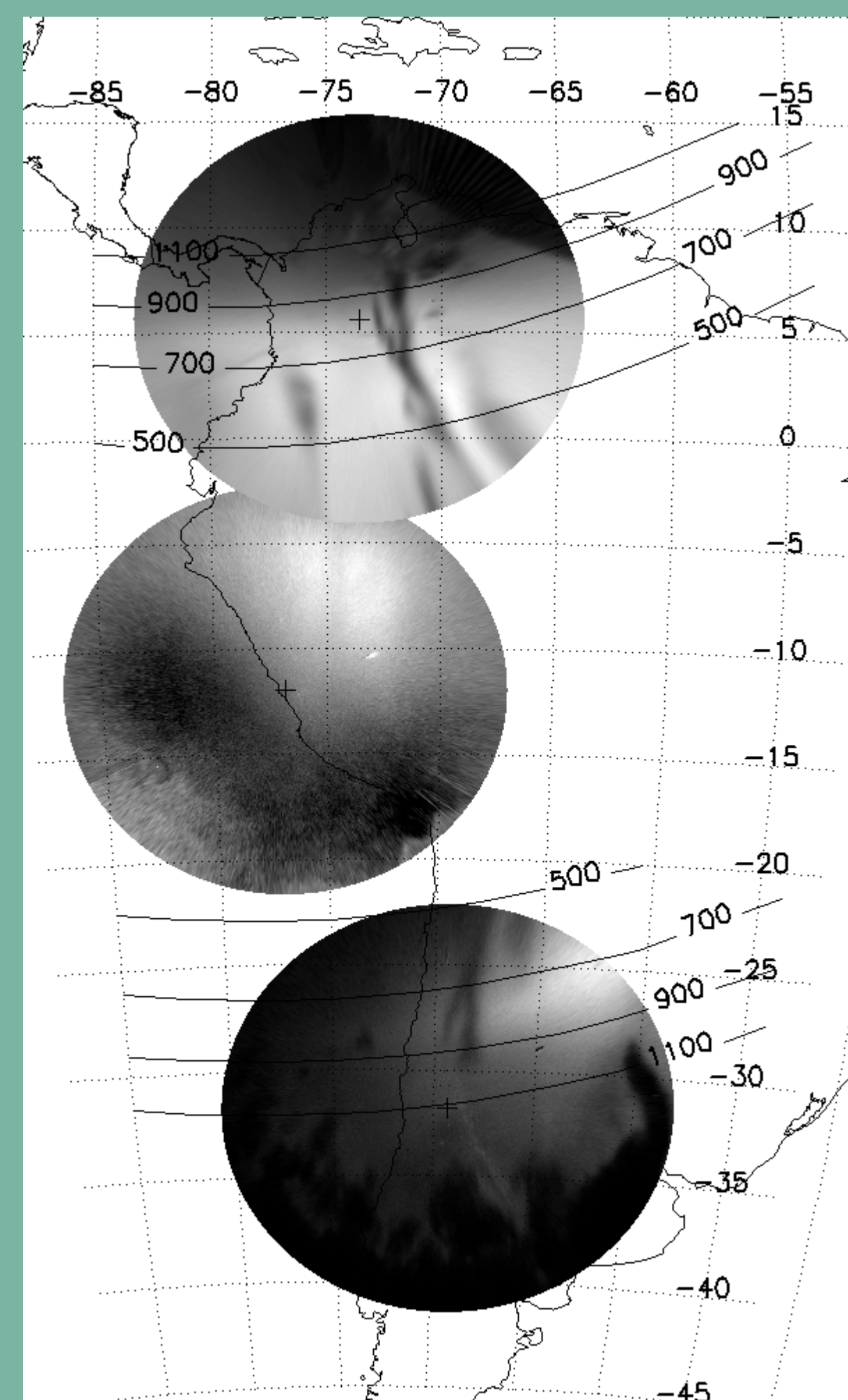


Figure 1: Three ASI images from Colombia, Peru, and Argentina on 12 Jan 2015. Black lines indicate magnetic apex altitude

In addition to the topics presented here, we are investigating differences in background emission, depletion velocity, and depletion width between conjugate sites (Hickey *et al.*, in prep).

In this work we compare observations of ESF depletions at conjugate sites. We compare their morphology and the presence of medium-scale irregularities.

Simultaneous Conjugate Observations

From Oct 2014 through Dec 2015 there are 179 total observations of depletions from Colombia and Argentina. During many of these nights it is cloudy at one of the sites. Out of those 179, 76 nights have depletions at one site and it is clear at the other. Of those 76, depletions are visible at both sites during 74 nights.

| Nights with depletion observations | | | |
|------------------------------------|---------------------------|--------------------------|-----------------------------|
| Depletions at either site | Good observing conditions | Depletions at both sites | Depletions at only one site |
| 179 | 76 | 74 | 2 |

- 97% of nights with depletions have conjugate depletions

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Comparing Conjugate Observations

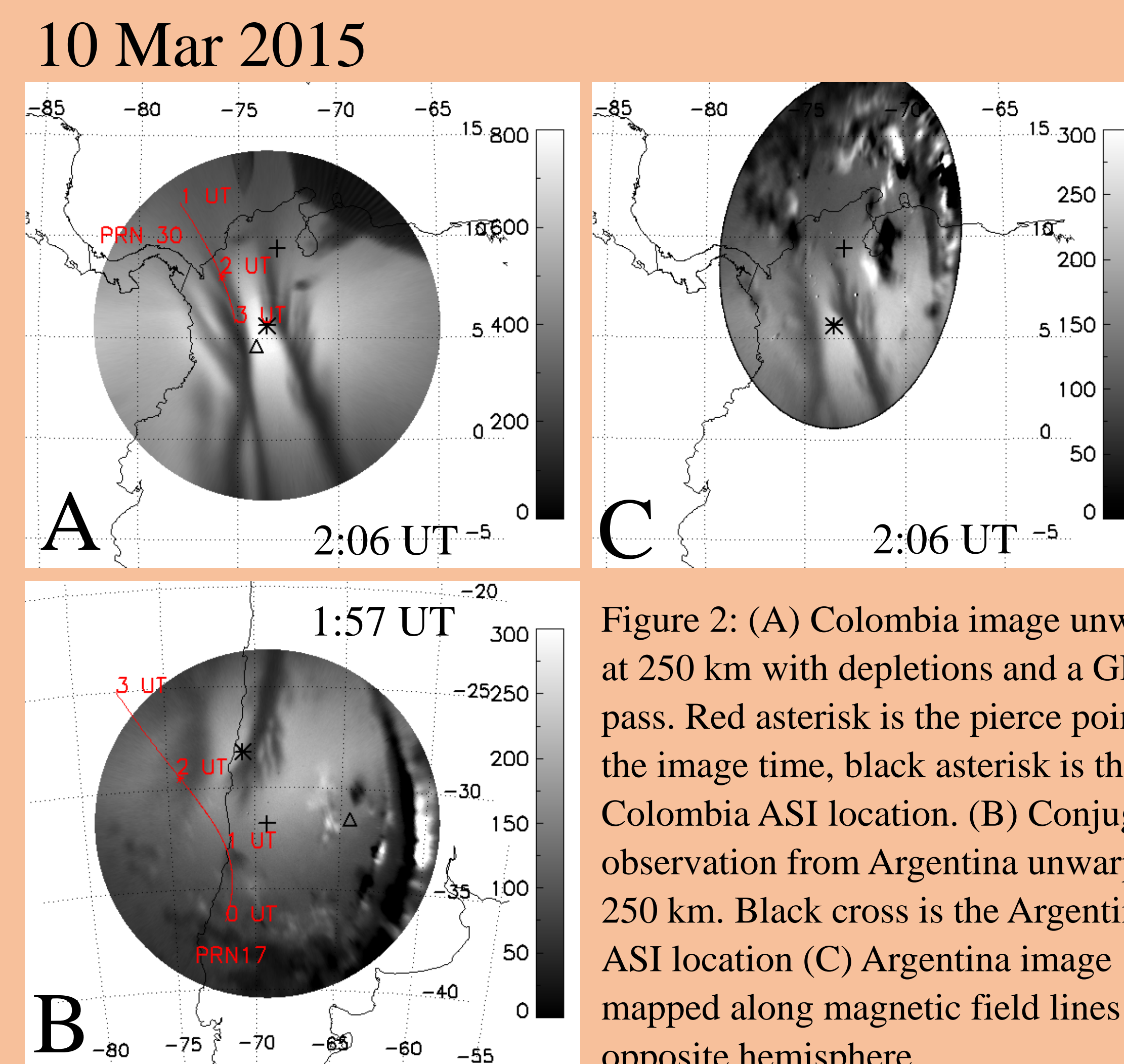


Figure 2: (A) Colombia image unwarped at 250 km with depletions and a GPS pass. Red asterisk is the pierce point at the image time, black asterisk is the Colombia ASI location. (B) Conjugate observation from Argentina unwarped at 250 km. Black cross is the Argentina ASI location (C) Argentina image mapped along magnetic field lines to the opposite hemisphere.

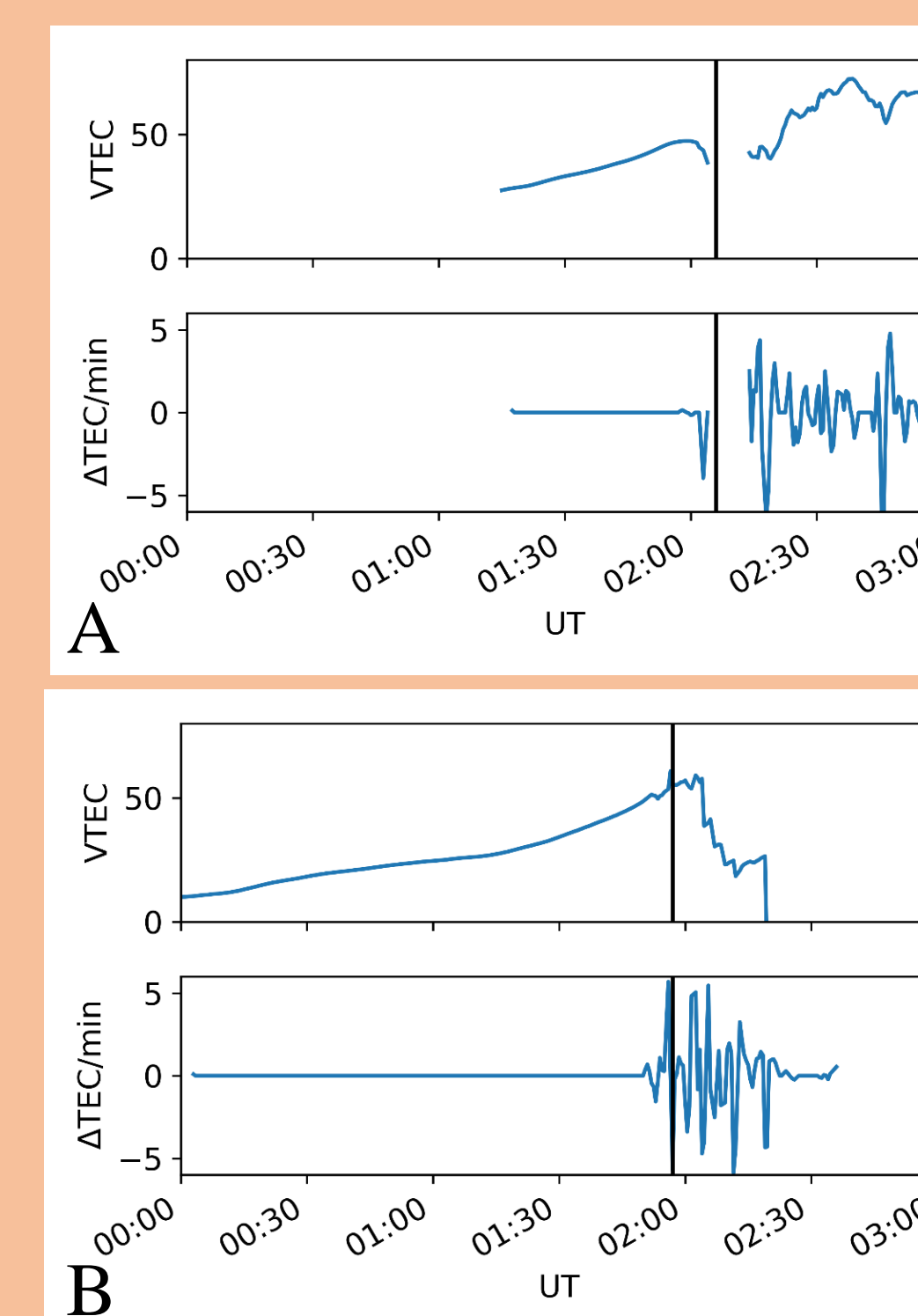


Figure 3: (A) Vertical TEC and rate of change of TEC in Colombia ASI FOV for Figure 2. Black line is the time of the image. (B) Same for Argentina.

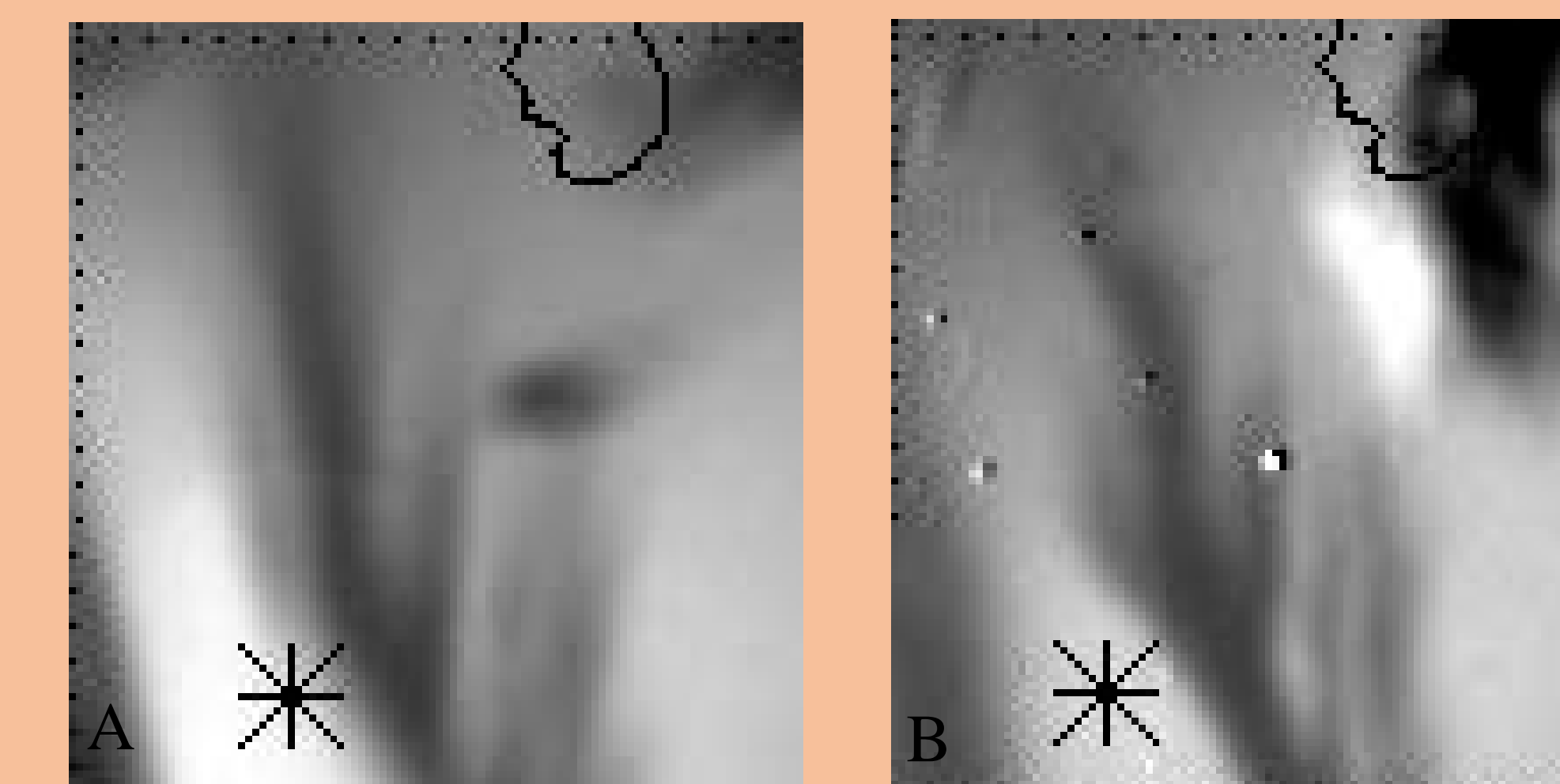


Figure 4: (A) Zoomed in region of Figure 2A from 5° to 10° N and 75° to 70° W. (B) Same region from Figure 2C.

- Depletions and TEC fluctuations are present at both sites.
- 50 km variations in airglow altitude do not have a major impact on conjunction of observations.
- Mapped image shows the same structure with the same bifurcations and only minor differences.

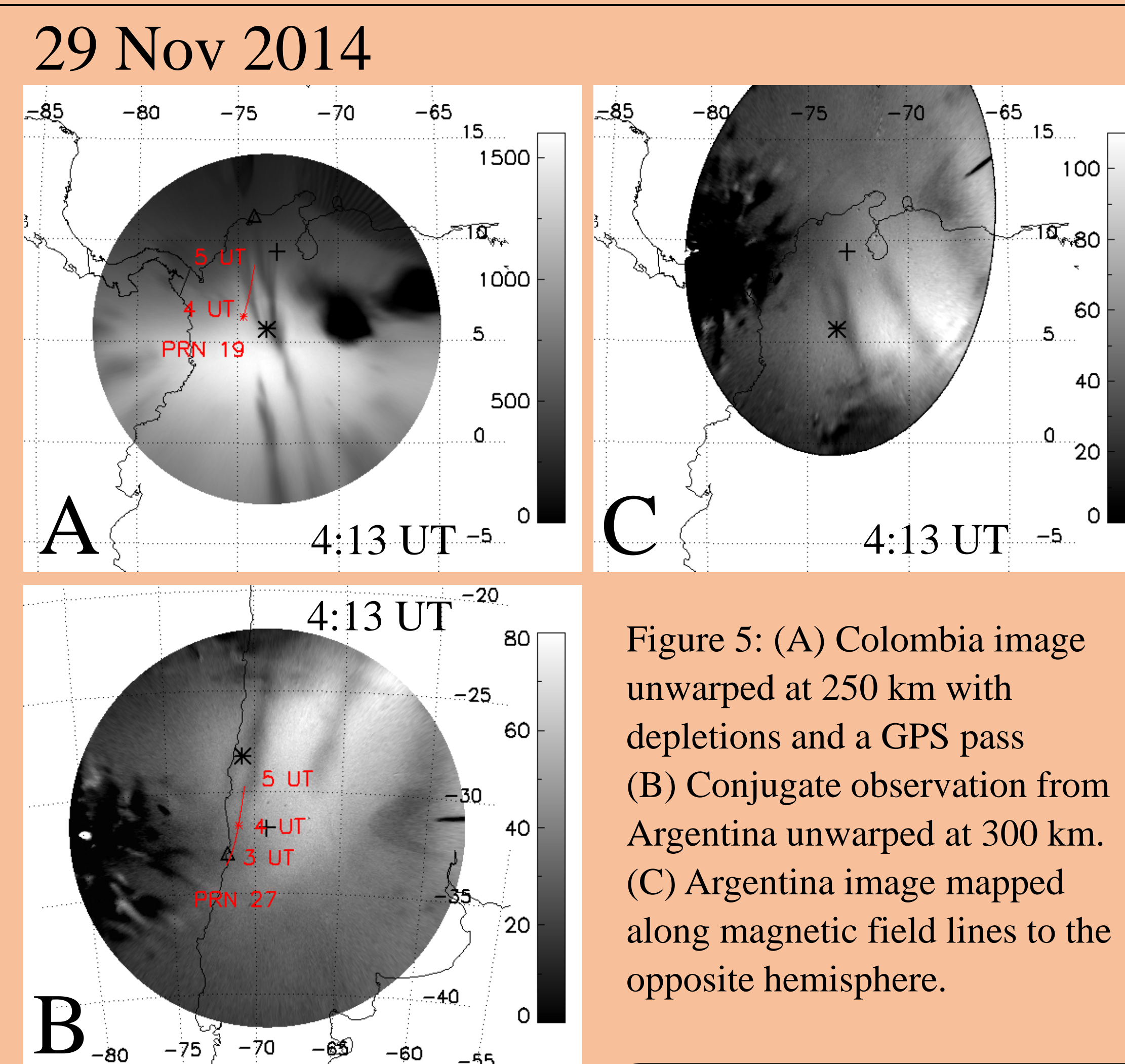


Figure 5: (A) Colombia image unwarped at 250 km with depletions and a GPS pass (B) Conjugate observation from Argentina unwarped at 300 km. (C) Argentina image mapped along magnetic field lines to the opposite hemisphere.

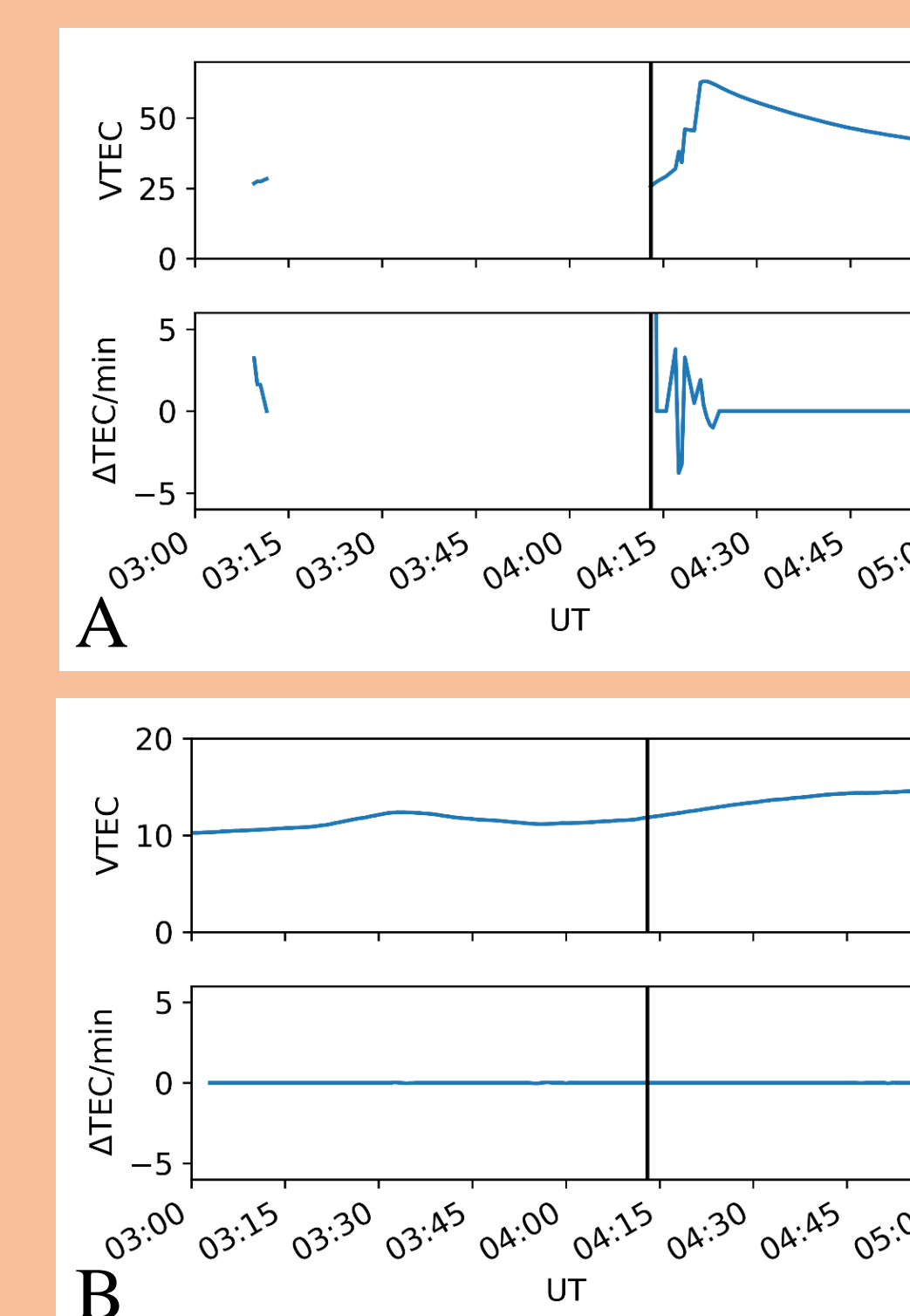


Figure 6: (A) Vertical TEC and rate of change of TEC in Colombia ASI FOV for Figure 5. The black line is the time of the image. (B) Same for Argentina.

- TEC fluctuations are not present in Argentina beyond the extent of the depletion. At the conjugate location of the pierce point there is a depletion

- TEC fluctuations occur within depletions at both sites for each of the cases presented here.
- Fluctuations do not occur outside of the local depletions, even if a depletion is present at the conjugate location

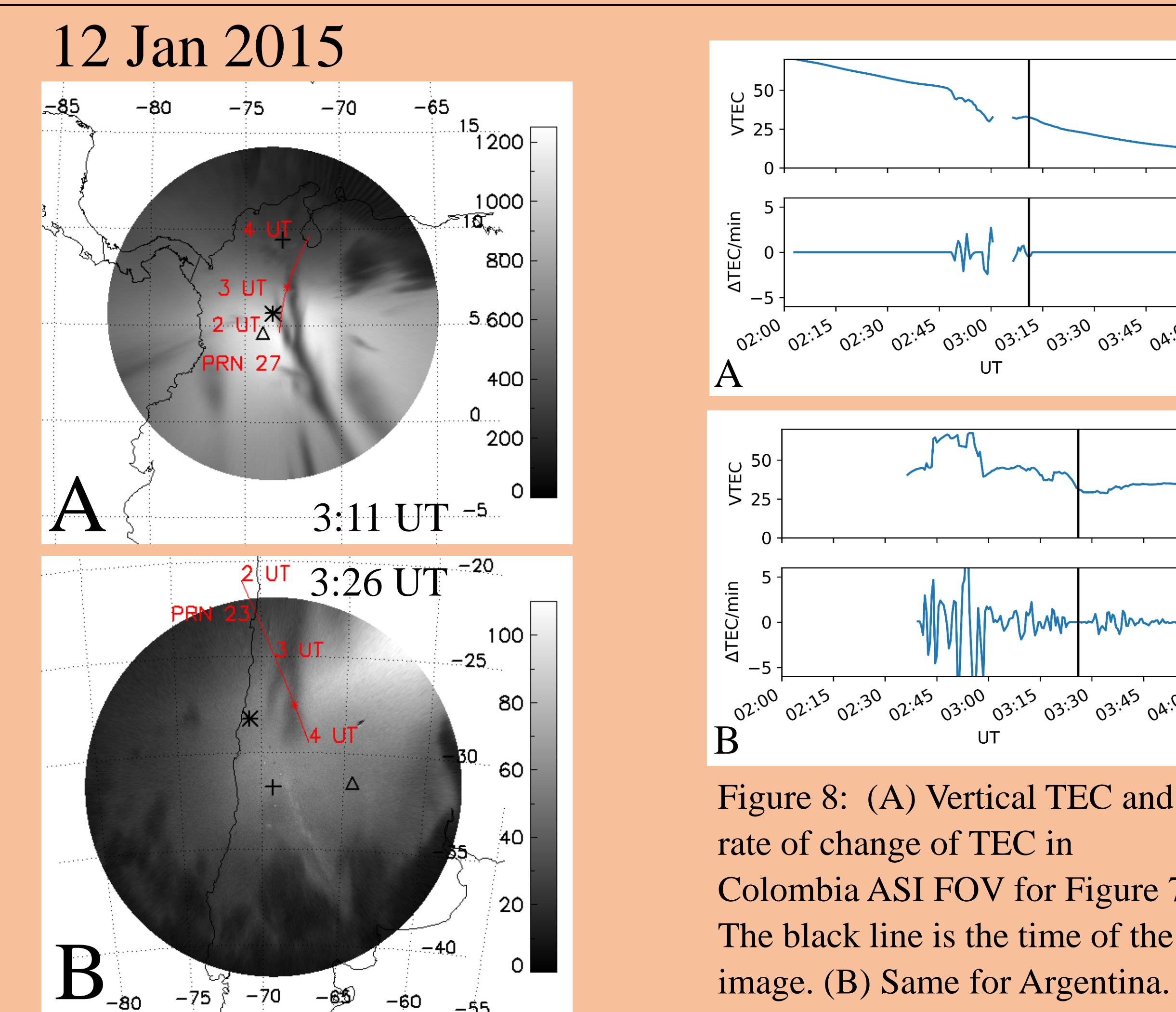


Figure 7: Same as Figure 2A and 2B but for 12 Jan 2015. (A) Unwarped at 250 km (B) Unwarped at 300 km

- Depletions and TEC fluctuations are present at both sites

Summary

- High rate of conjugate depletions, 74 out of 76 (97%)
- Similar morphology, including small-scale bifurcated structures, between sites
- Conjugate depletions show similar conjugate TEC fluctuations
- Depletions do not reach the same footpoint in the conjugate hemisphere. TEC fluctuations are also absent so the effect is not due to lack of airglow contrast.

References:

Hickey *et al.* (in prep), Conjugate Observations of ESF in South America
 Ledvina, B. M., and J. J. Makela (2005), First observations of SBAS/WAAS scintillations: Using collocated scintillation measurements and all-sky images to study equatorial plasma bubbles, GRL.
 Mendillo, M., *et al.* (2005), Observations and modeling of the coupled latitude-altitude patterns of equatorial plasma depletions, JGR