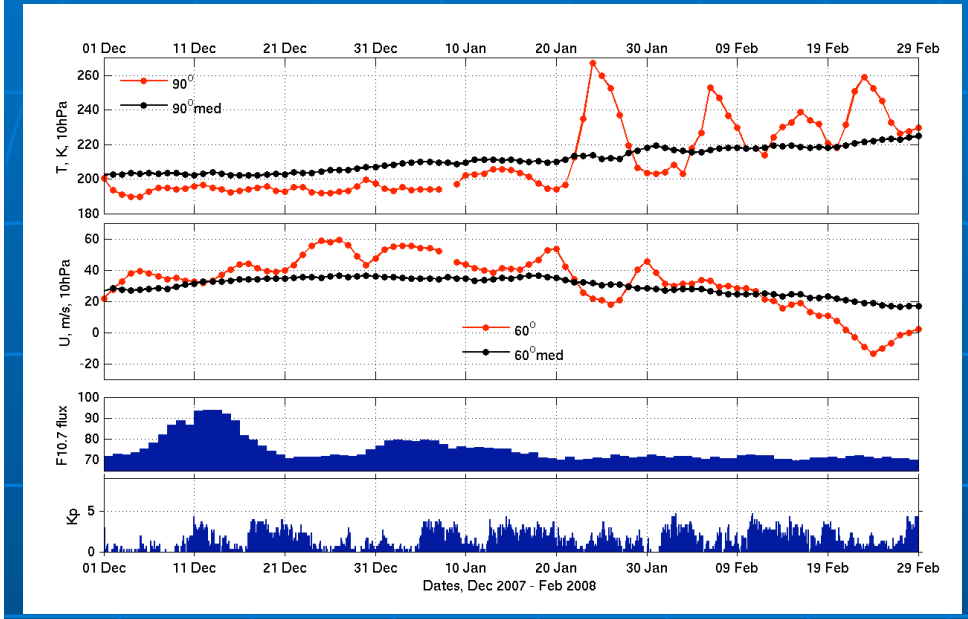
Ionospheric disturbances associated with stratospheric sudden warmings

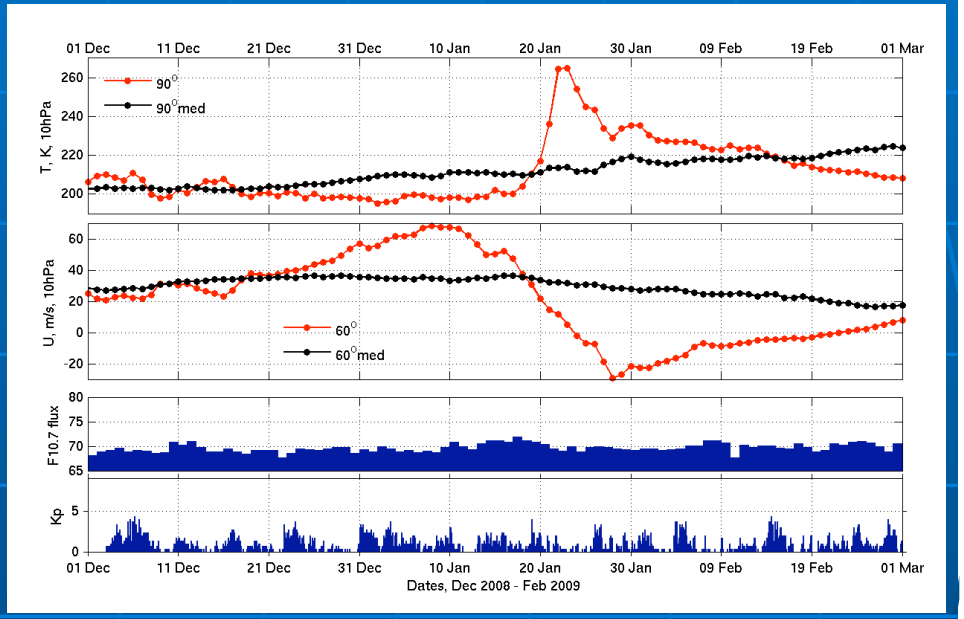
L. Goncharenko, A. Coster, W. Rideout
MIT Haystack Observatory
J. Chau, *Jicamarca Radio Observatory*
C. Valladares, *Boston College*

Stratospheric and geomagnetic conditions

Winter of 2007-2008

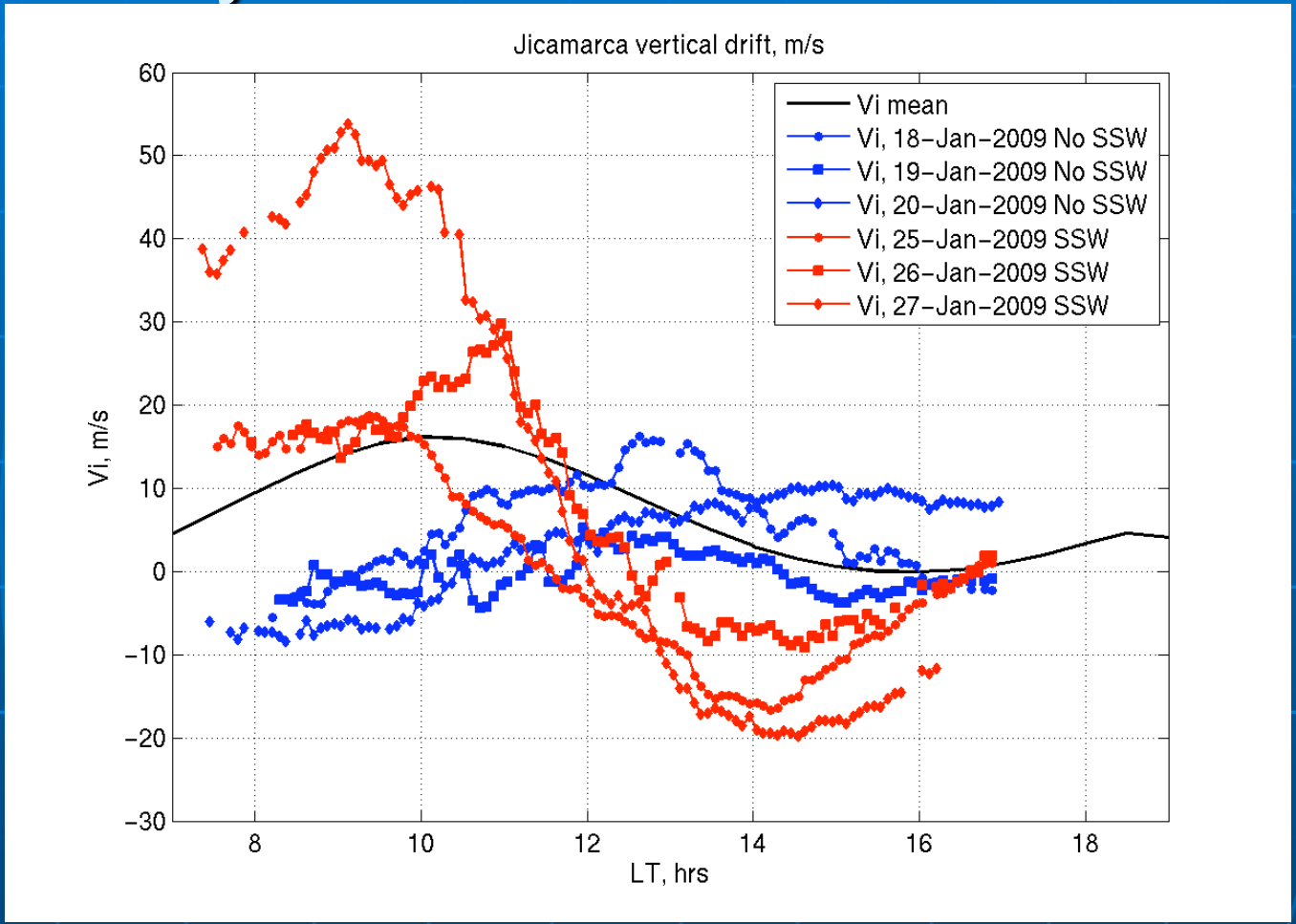


Winter of 2008-2009



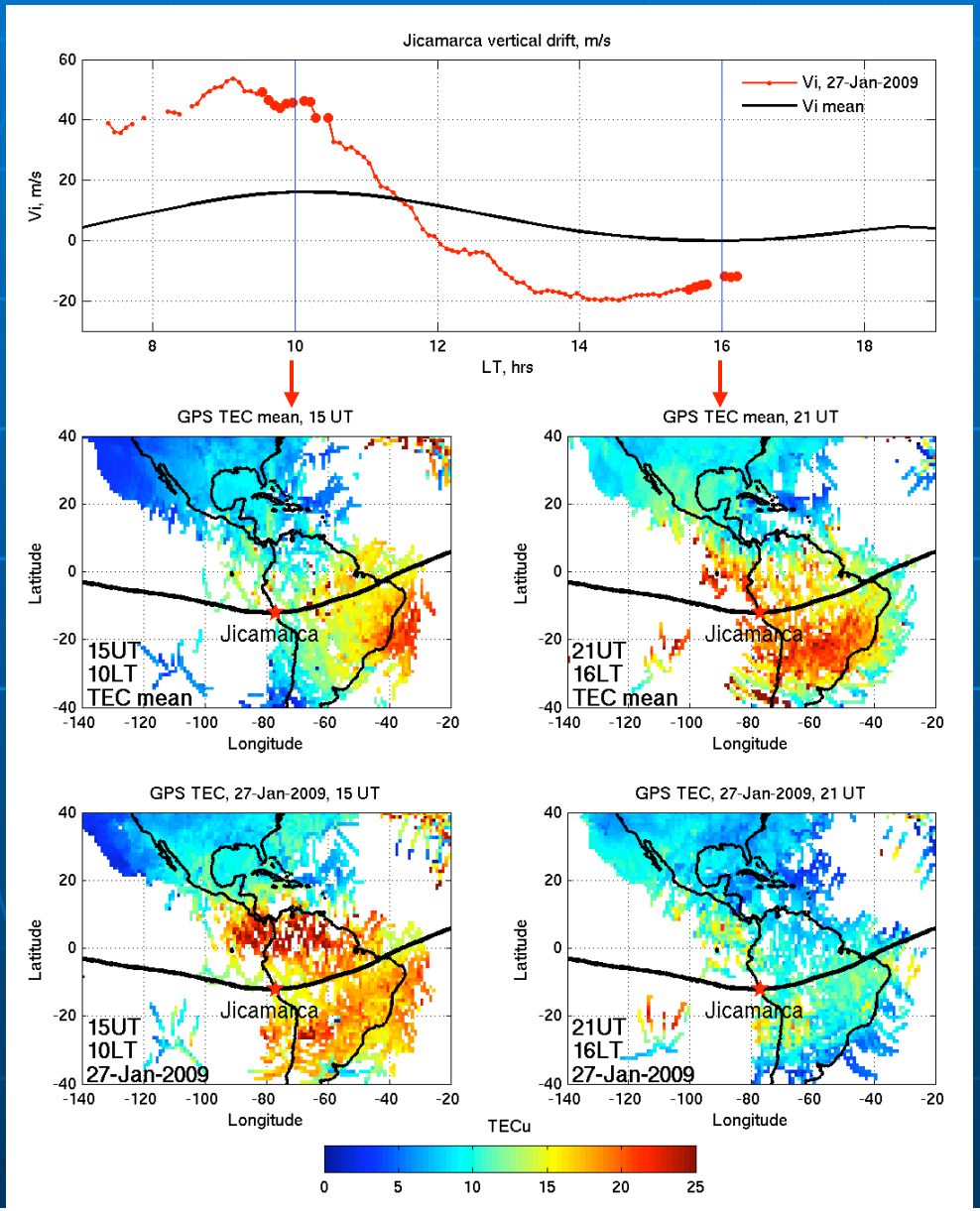
- 4 stratospheric sudden warmings in January-February 2008; record-breaking stratospheric temperature in January 2008 event
- 1 stratospheric sudden warming peaking in end of January 2009; major warming, the strongest and most prolonged on record
- Solar minimum, geomagnetically quiet periods

January 2009: Jicamarca vertical drift



- Strong 12-h perturbation in vertical drift
- Persistent for several days
- Similar to the drift during stratwarming of Jan 2008 (Chau et al., 2009)

Jicamarca drift and GPS TEC

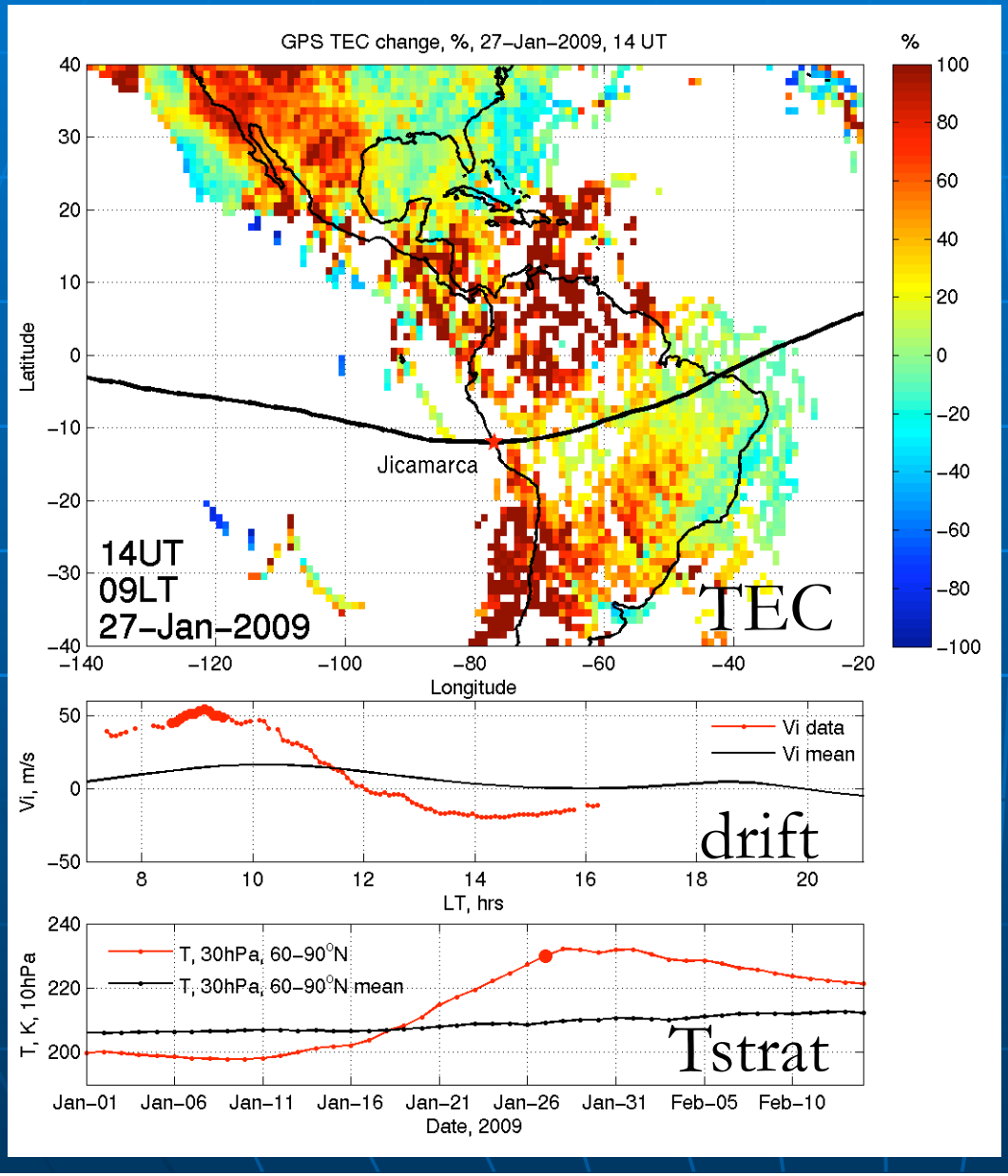


Jicamarca vertical drift

GPS TEC at 15UT and 21UT before stratwarming

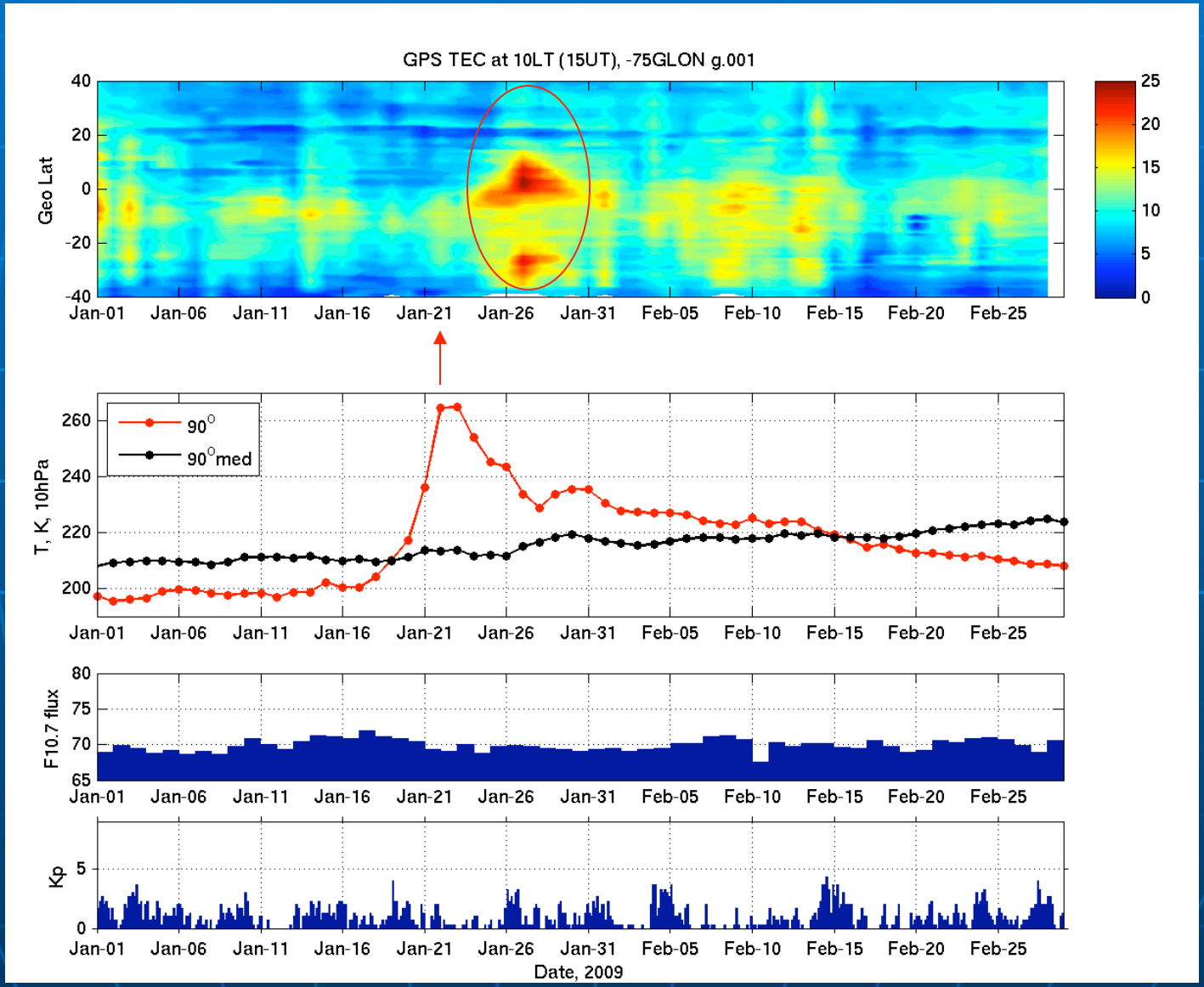
GPS TEC at 15UT and 21UT during stratwarming

GPS TEC during warming: morning sector

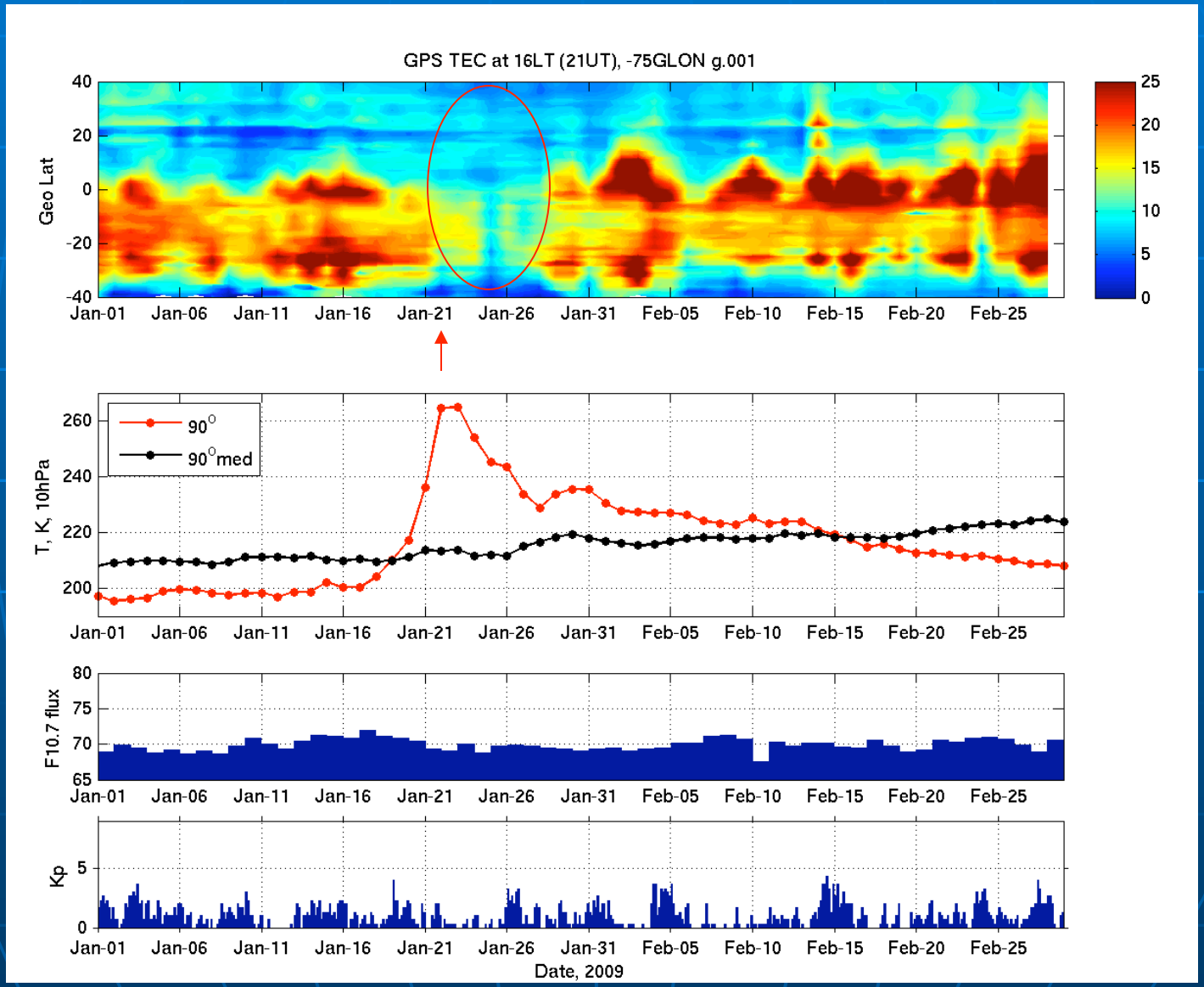


- During stratwarming, TEC increases in excess of 50-100% in the morning
- Large upward drift at Jicamarca
- The magnitude of increase is similar to effects of severe geomagnetic storms

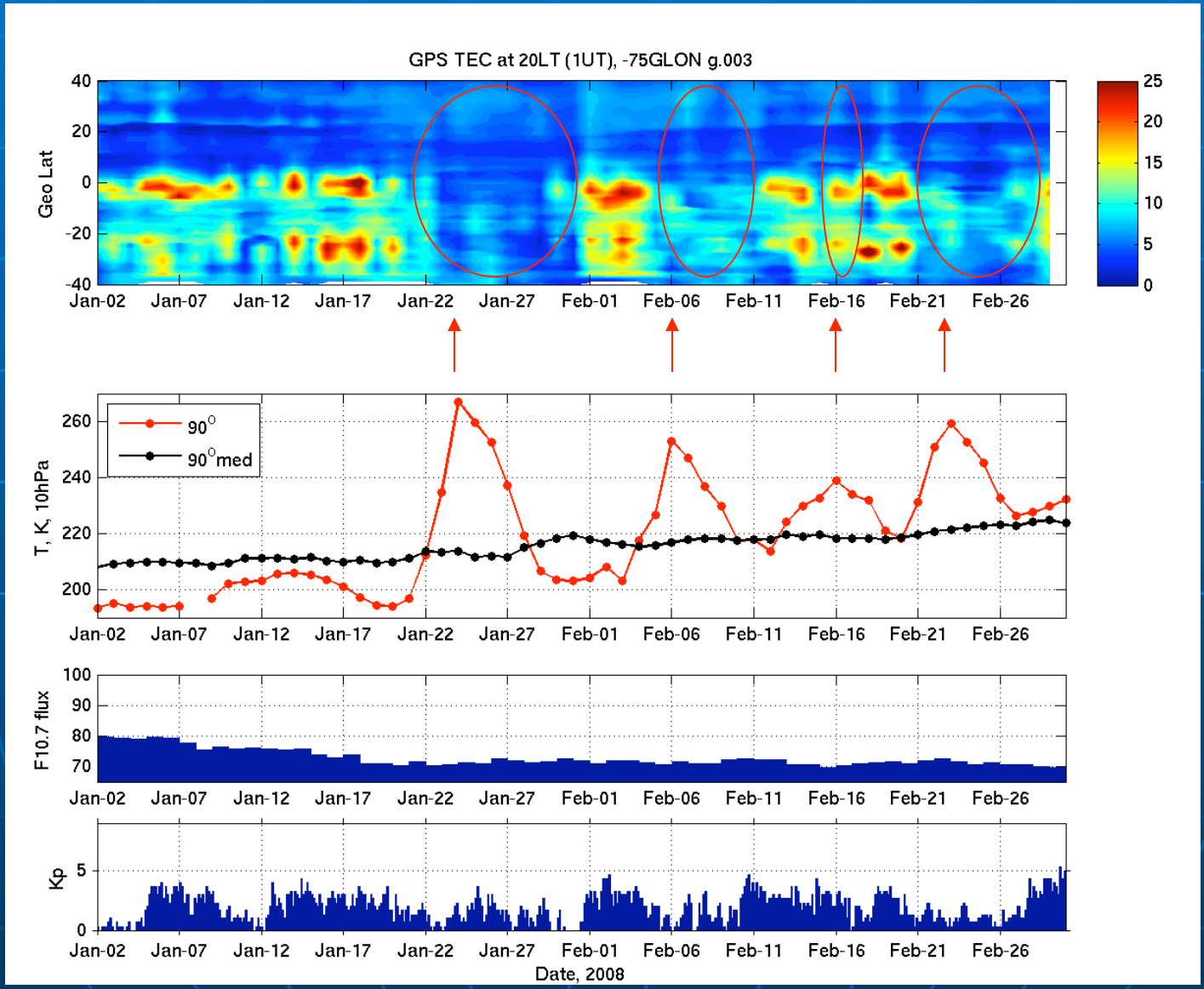
GPS TEC Jan-Feb 2009, 75°W, 10LT



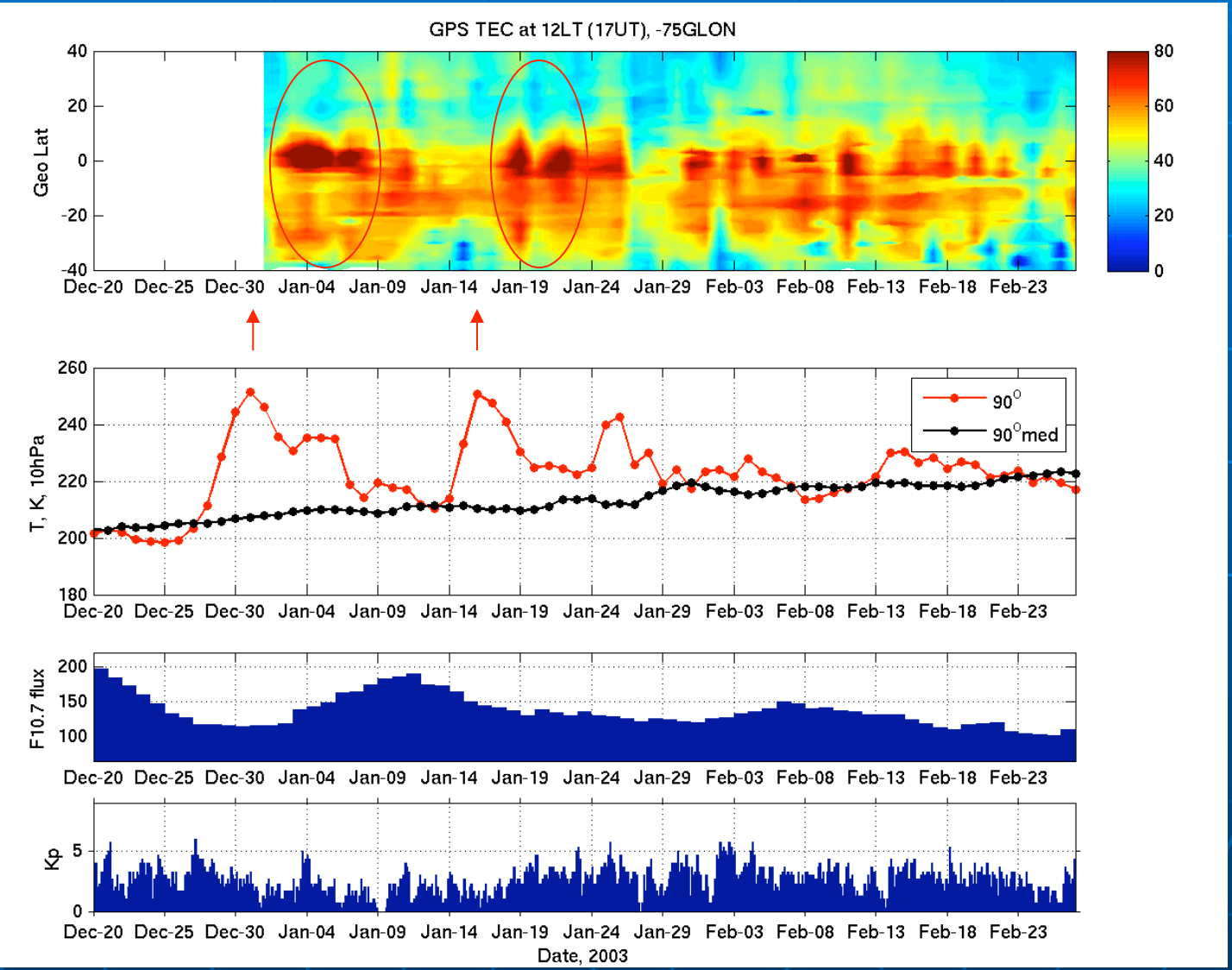
GPS TEC Jan-Feb 2009, 75°W, 16LT



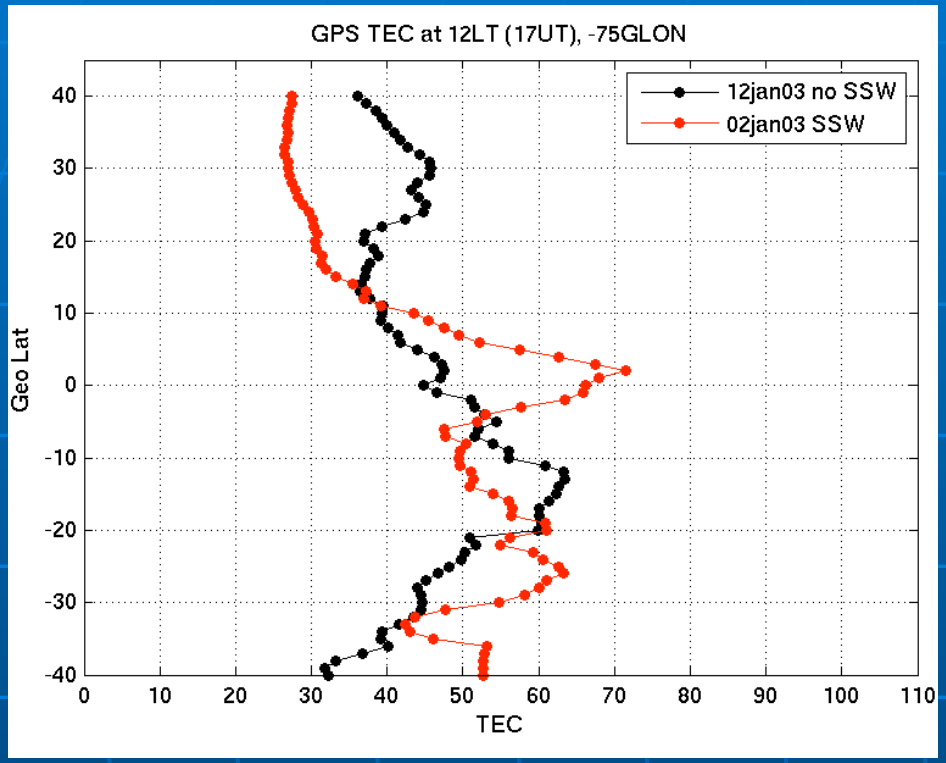
GPS TEC Jan-Feb 2008, dusk sector

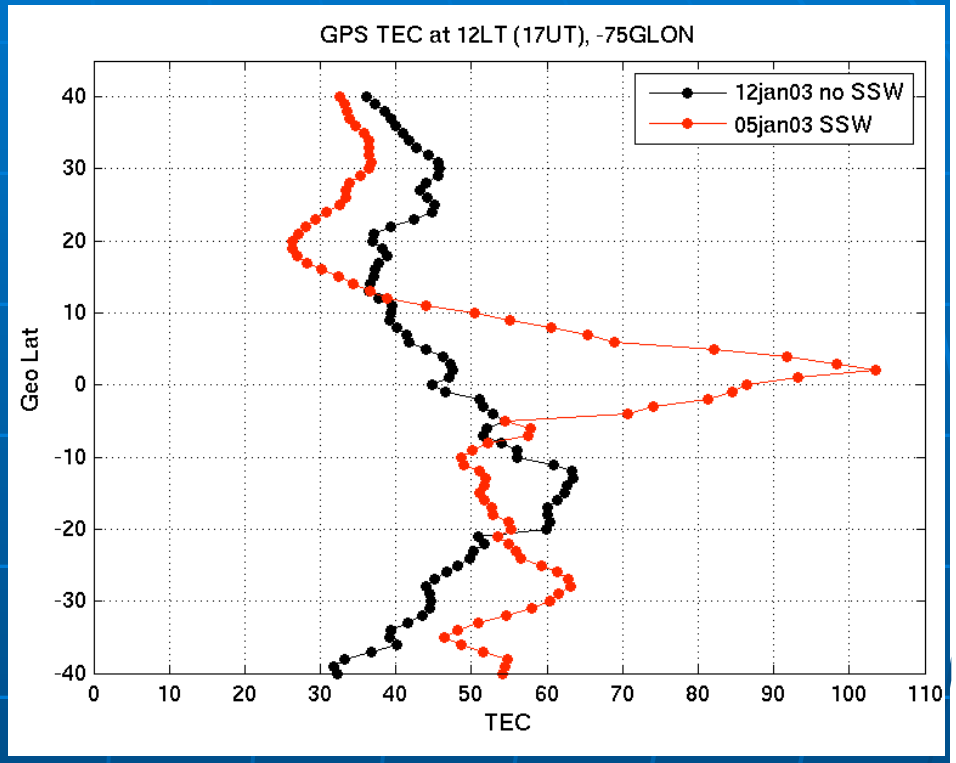


High solar flux: winter of 2003, 12LT



Winter of 2003, 12LT





No SSW: Jan 12, 2003, F107=173, Kp=2, Ap=8

SSW: Jan 2, 2003, F107=118, Kp=2-, Ap=6

SSW: Jan 5, 2003, F107=148, Kp=2, Ap=7

A plausible cause

- **Major factors: planetary waves + tides**
- Stratospheric warming results from interaction of planetary wave with zonal mean flow (*Matsuno*, 1971)
- Large planetary wave activity before SSW
- Planetary waves propagate upward and to lower latitudes and are present at the lower thermosphere level (*Pancheva et al*., 2008,2009, *Fuller-Rowell et al*., 2008)
- Interaction of planetary wave with semidiurnal tide modulates the 12-h wave amplitude and E-region dynamo
  - Seasonal and longitudinal variation expected (*Oberheide et al*., 2008, *Forbes et al*., 2008, *Pedatella et al*., 2008)

Summary

- Evidence of dramatic changes in low-latitude electron density during stratospheric sudden warmings
- 7 cases of ionospheric effects out of 7 cases of SSW
- Consistent with increase in Jicamarca electric field data and E-region dynamo mechanism
- Strong 12-h signature
- Increase in TEC in the morning sector by 50-150%; suppression in the afternoon by ~50-150%
- Disturbances extend to middle latitudes
- Phenomena observed for both low and high solar flux conditions