

**Mid-Latitude Thermosphere-Ionosphere Na (TINa) Layers
Observed with High-Sensitivity Na Doppler Lidar over
Boulder (40.13°N, 105.24°W)**

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Introduction

The STAR Na Doppler lidar observations made at Boulder (40.13°N, 105.24°W), Colorado reveal the thermosphere-ionosphere Na (TINa) layers in the E region up to ~150 km, in addition to the permanent Na layers from ~75 to 110 km. We present here the full range (75–150 km) plots of Na number density, relative density perturbations, and volume mixing ratio for the six nights described in the article as Figures S1 and S2. Many wave features are shown in the Na layers over a large altitude range, but they are not the focus of the article itself.

Furthermore, the Figure 1 in Buonsanto et al. (1993) that was referenced in the Discussion section is shown as Figure S3 for the convenience of readers. This Figure S3 illustrates the statistical mean of F-region ion transport at Millstone Hill measured by an incoherent scatter radar, where geographic and geomagnetic latitudes are similar to those of Boulder.

The dip angle for Boulder was calculated for the year 2013 using an online tool at http://www.geomag.bgs.ac.uk/data_service/models_compass/home.html.

The ICON wind data used to derive the Hough Mode Extension (HME) fields were taken from ICON wind version 4, which can be downloaded from <ftp://icon-science.ssl.berkeley.edu/pub/LEVEL.2/MIGHTI/>

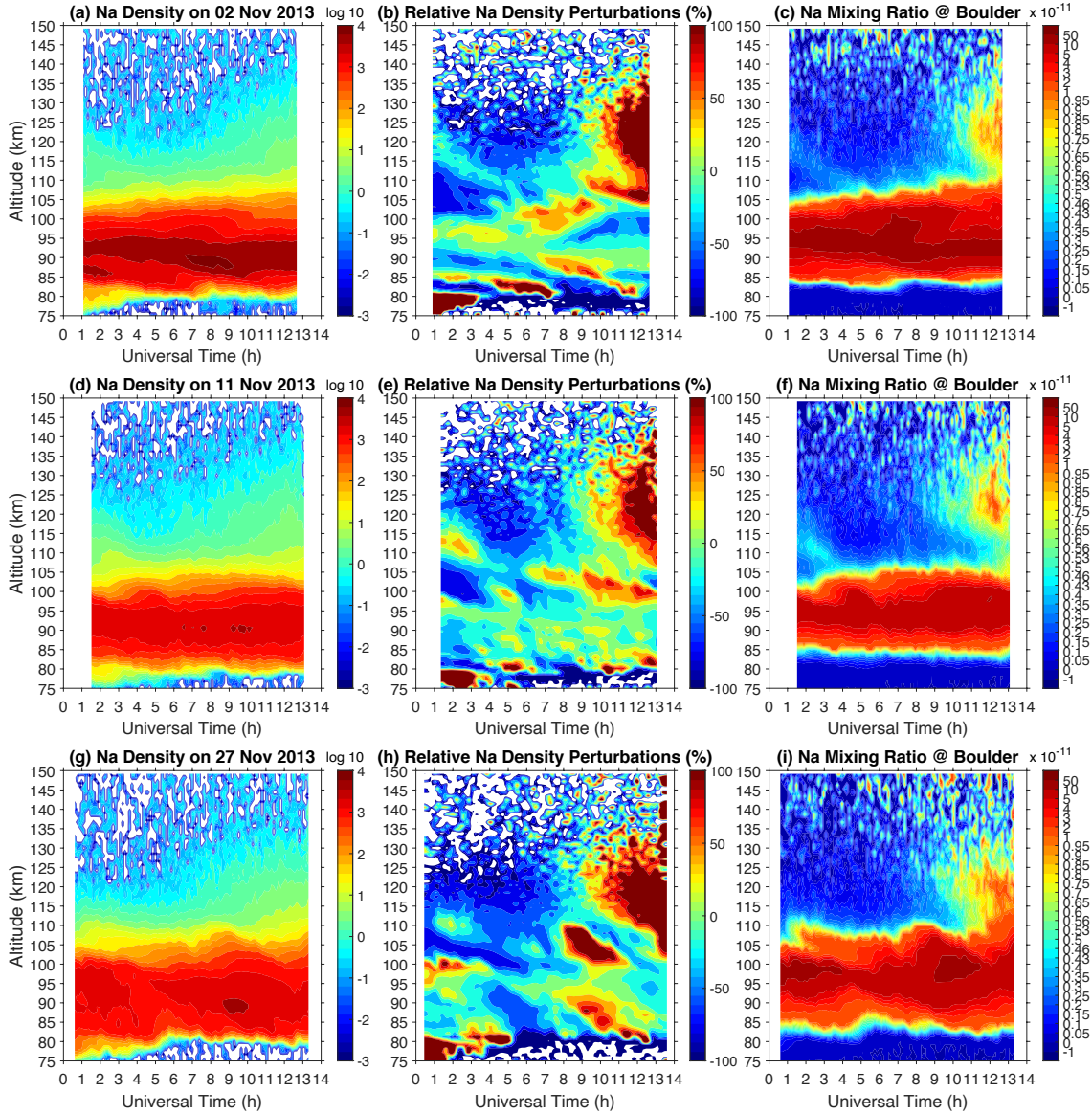


Figure S1. The full range (75–150 km) contours of Na density, relative density perturbation, and volume mixing ratio observed on 2, 11, and 27 November 2013 over Boulder (40.13°N, 105.24°W), Colorado with a high-sensitivity STAR Na Doppler lidar. The Na densities and mixing ratios were derived at resolutions of 7.5 min and 0.96 km. Note that 7 UT corresponds to Boulder local midnight.

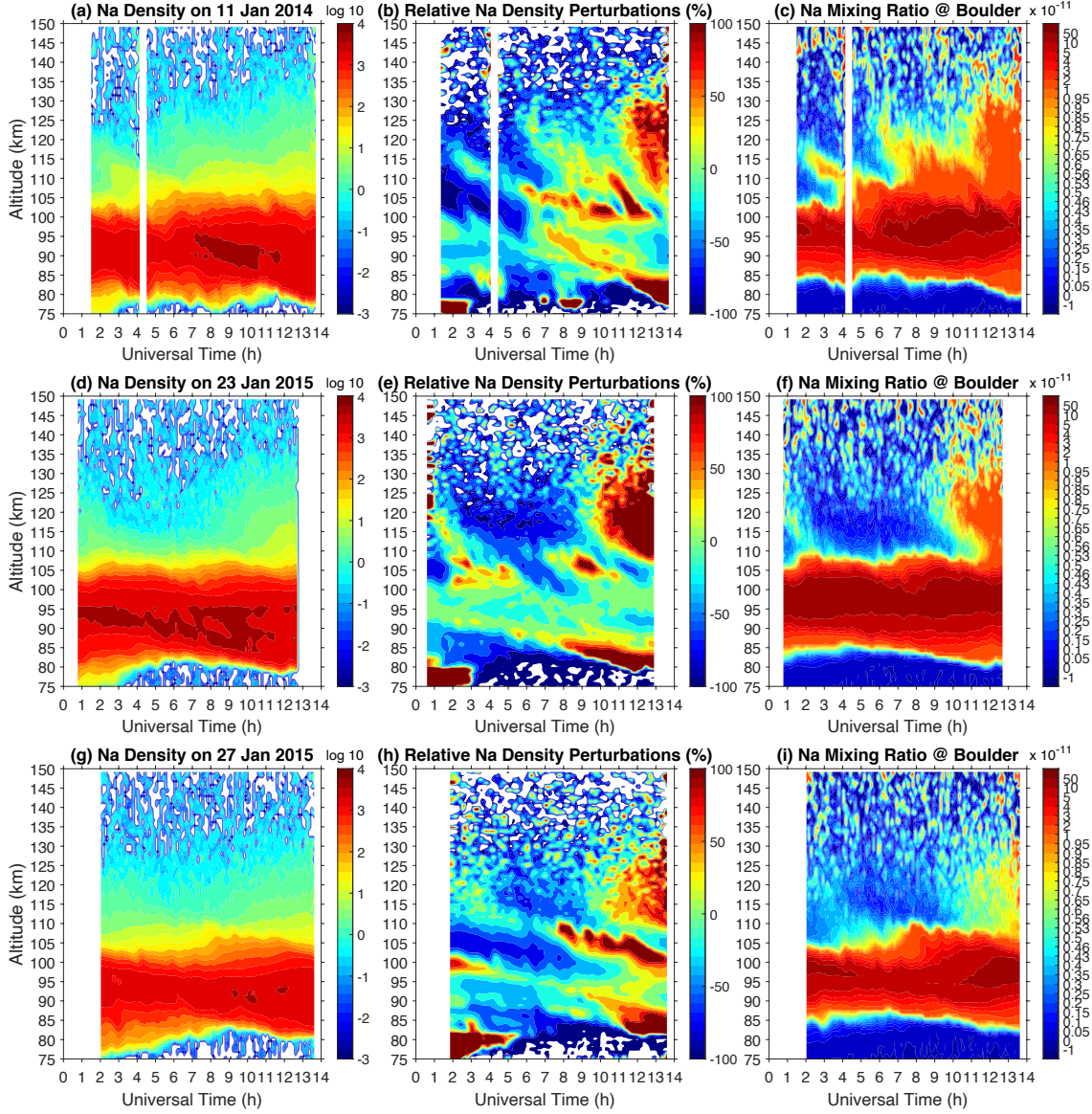


Figure S2. The full range (75–150 km) contours of Na density, relative density perturbation, and volume mixing ratio on 11 January 2014 and 23 and 27 January 2015 over Boulder (40.13°N, 105.24°W), Colorado with a high-sensitivity STAR Na Doppler lidar. The Na densities and mixing ratios were derived at resolutions of 7.5 min and 0.96 km. Note that 7 UT corresponds to Boulder local midnight.

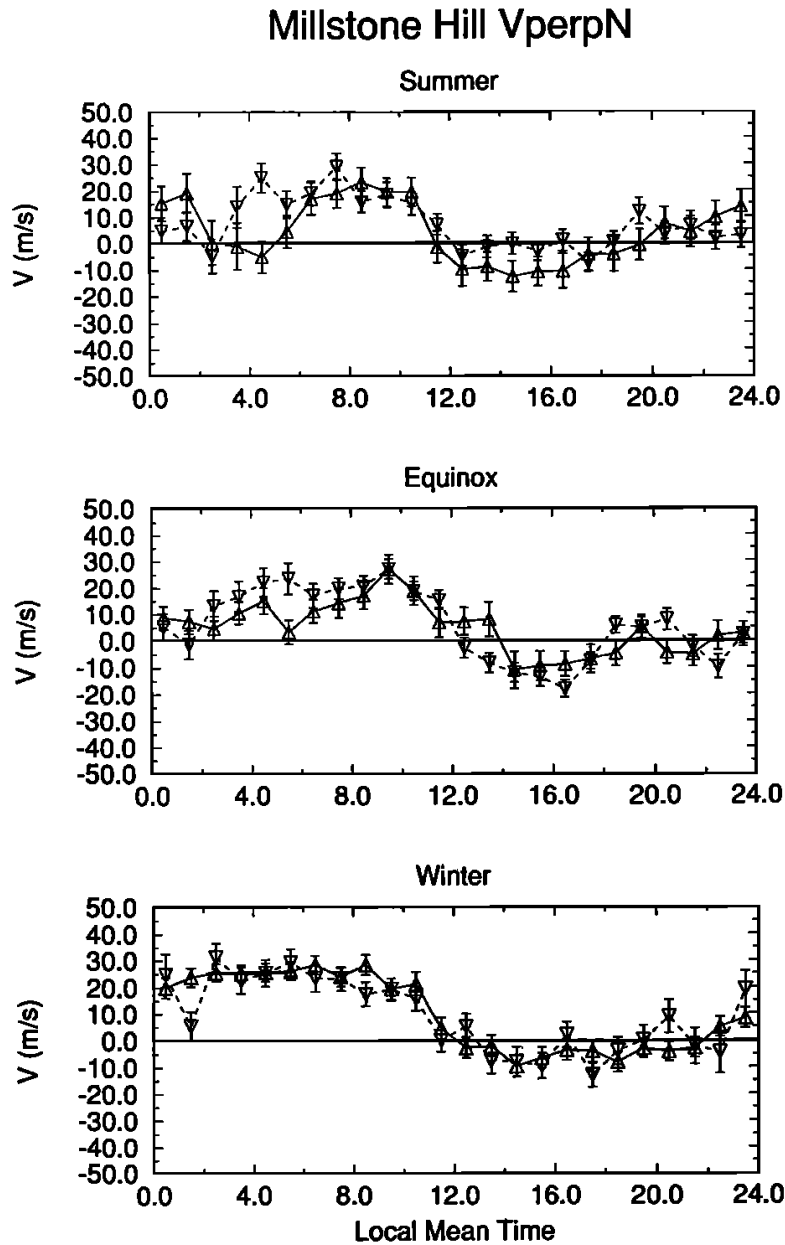


Fig. 1. Mean daily variation of ionization drifts perpendicular to the magnetic field, positive northward ($V_{\perp N}$) above Millstone Hill for solar minimum (downward triangles) and solar maximum (upward triangles) for summer (top), equinox (middle), and winter (bottom).

Figure S3. Millstone Hill Incoherent Scatter Radar (ISR) measurements of ion drifts perpendicular to the magnetic field, where are taken from Buonsanto et al. (1993). [Buonsanto, M. J., Hagan, M. E., Salah, J. E., & Fejer, B. G. (1993). Solar cycle and seasonal variations in F region electrodynamics at Millstone Hill. *Journal of Geophysical Research*, 98, 15,677-15,683. <https://doi.org/10.1029/93ja01187>]