Longitudinal and Temporal Variability of the Midnight Temperature Maximum

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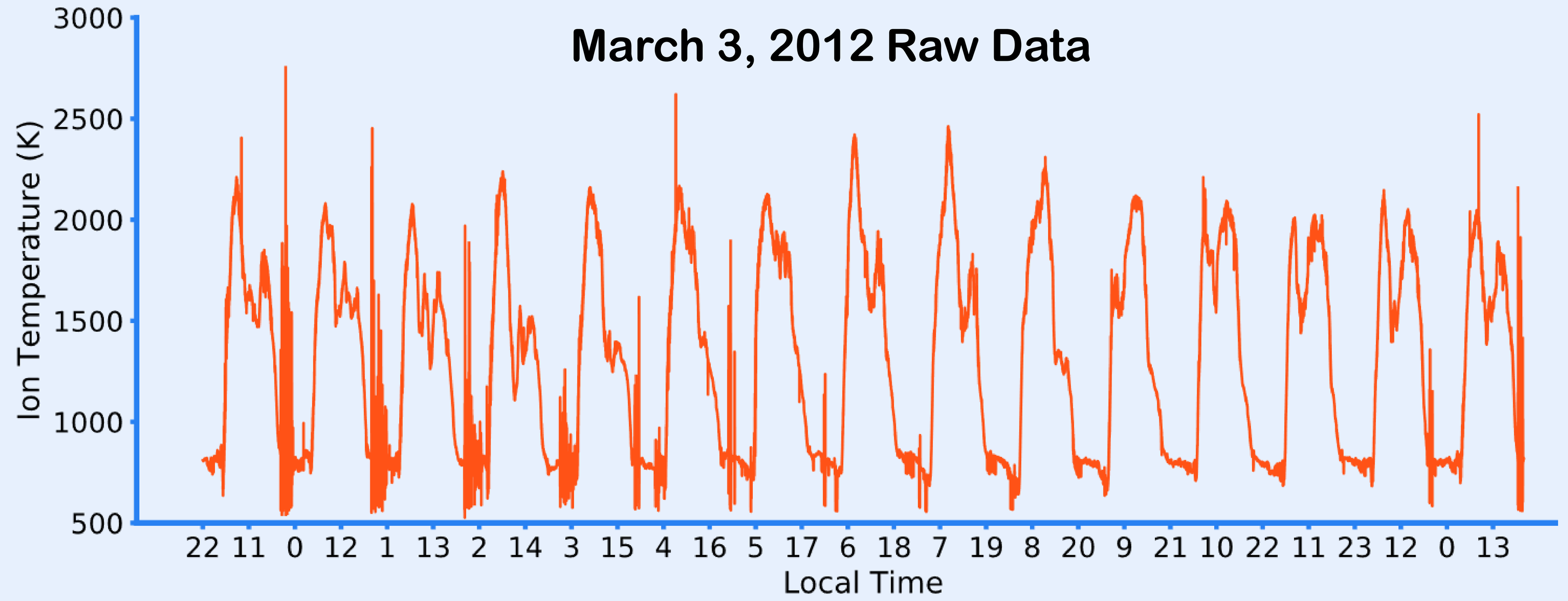
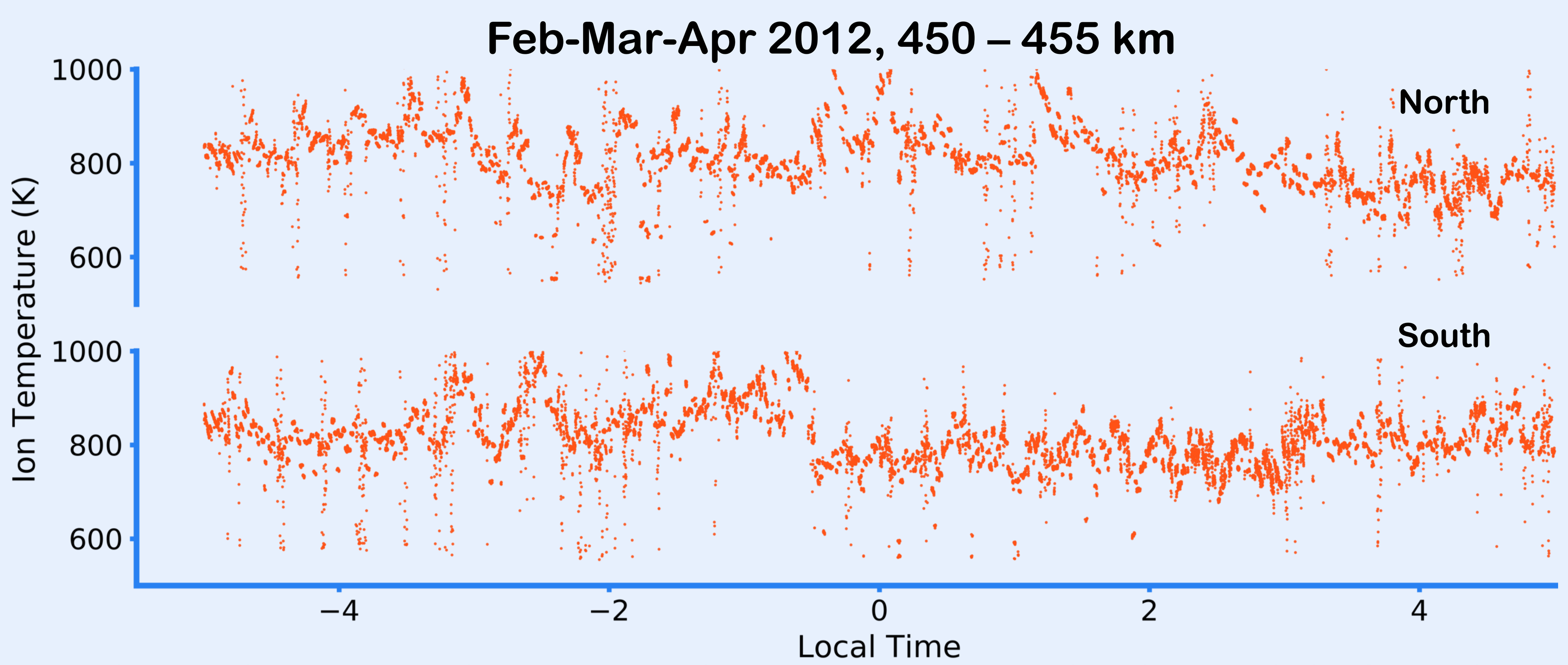
Introduction

The Midnight Temperature Maximum (MTM) is a neutral temperature peak (~50-100K) occurring at low latitudes around midnight local time in an otherwise cooling ionosphere. The MTM can also modulate the neutral wind at ionospheric F-region heights from its typical nighttime patterns. The MTM has been studied since the 1960's however its causal mechanism remains inconclusive and its variability in longitudes and times understudied. This study combines ion temperature data collected by the Ion Velocity Meter onboard the Communications/Navigation Outage Forecasting System (C/NOFS) platform with machine learning techniques to identify and characterize the relatively small signal of the MTM.

C/NOFS Data and Methods

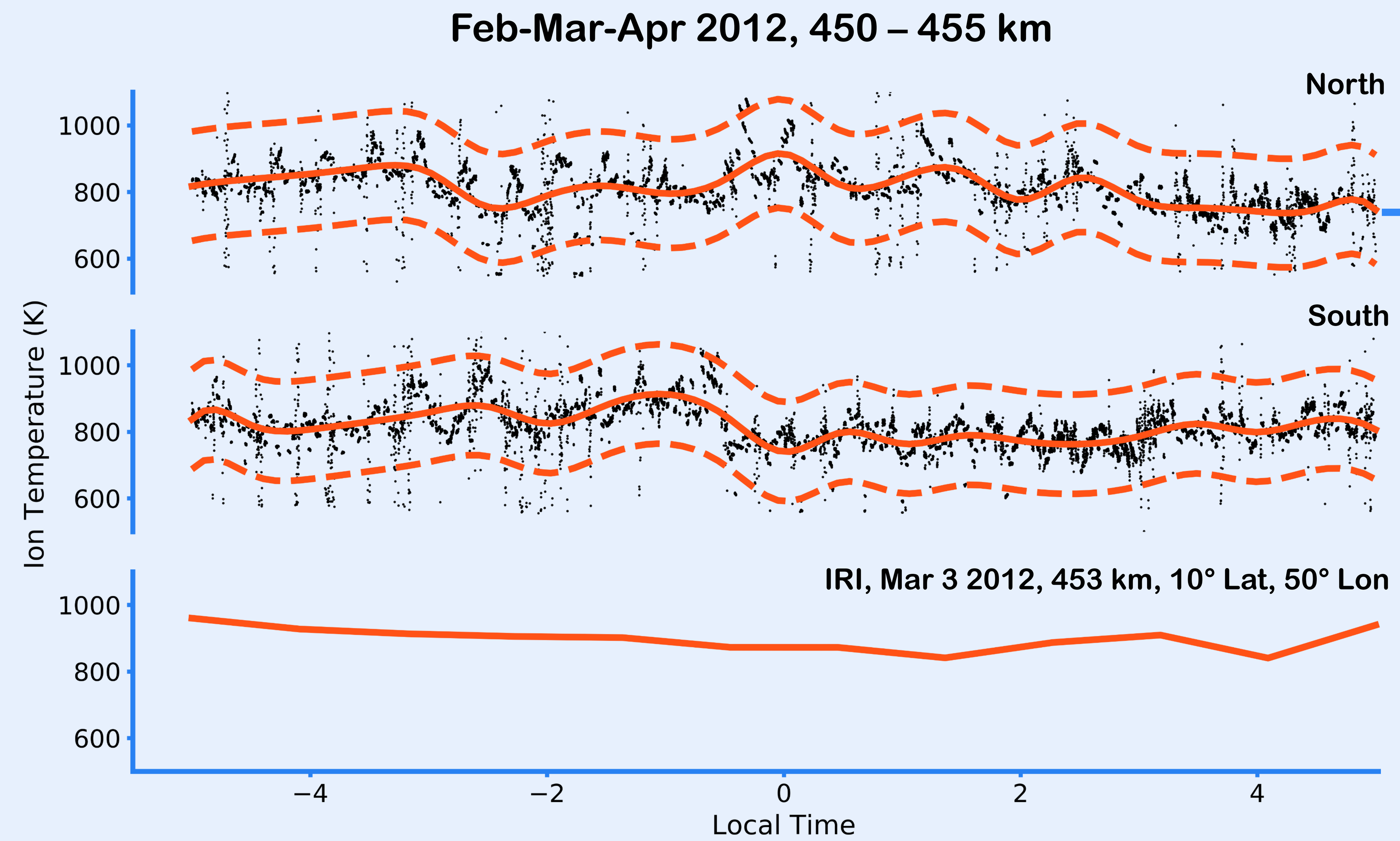


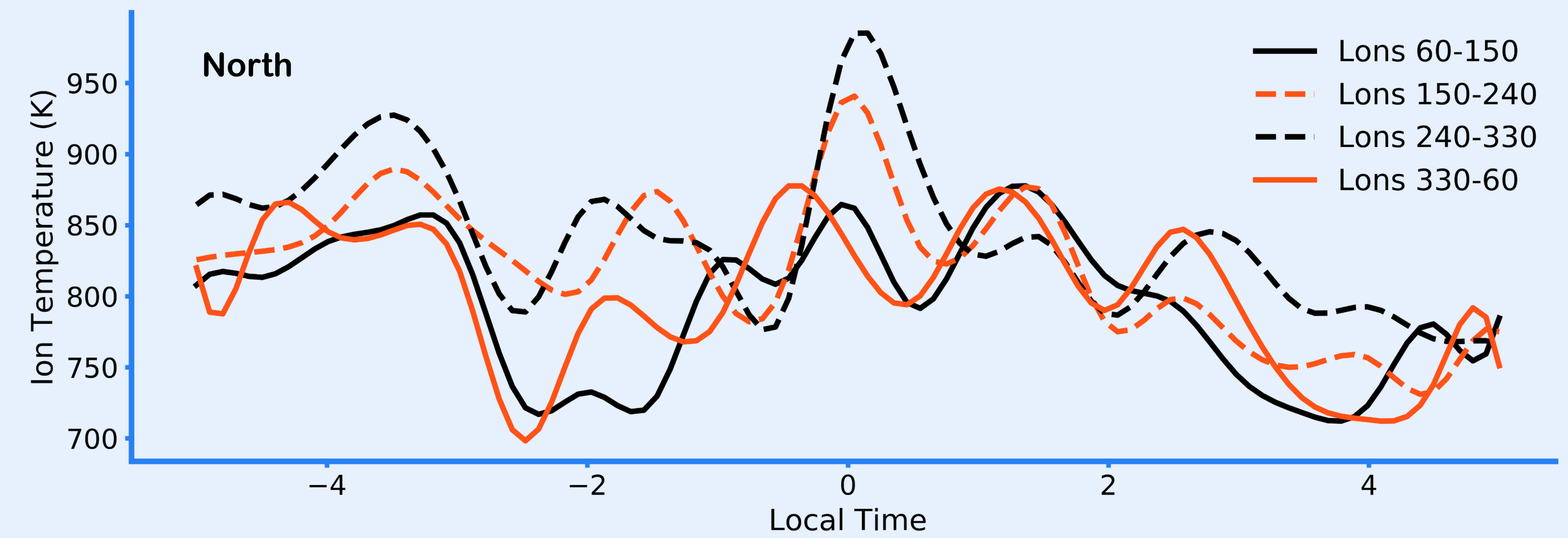


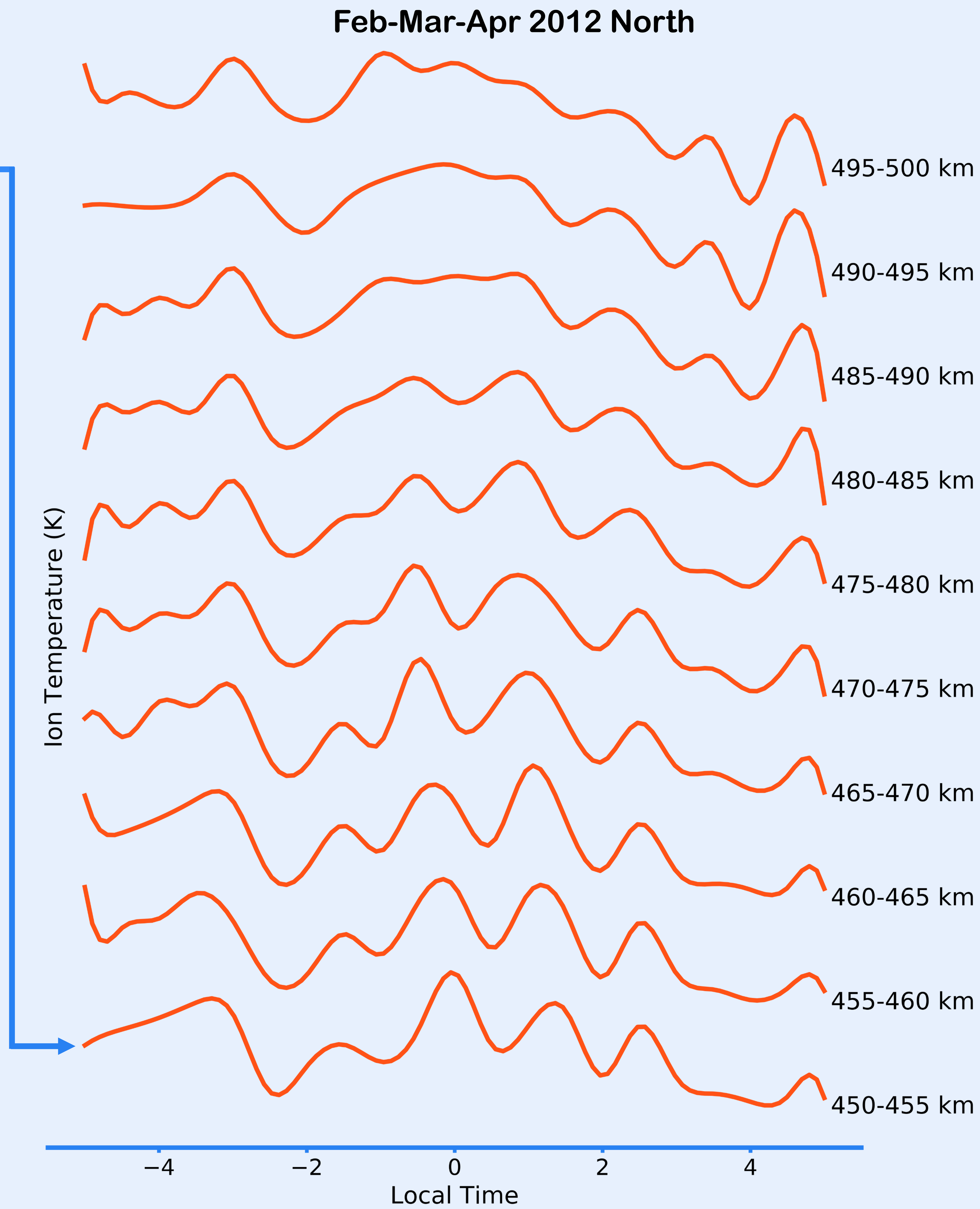
Machine learning (regression) uses a standard model for data $y = f(x) + \epsilon$ where epsilon gets minimized. Different ML models use different functions f(x) to fit and represent the data (y) up to some error epsilon. In this study I use a penalized uniform b-spline basis which depends on the number of knots chosen and a penalization parameter. The method employed was completed in three steps:

1. Data grouped by season and 5 km altitude ranges from 400 to 745 km
2. Grid search performed over number of knots, penalization parameter, and 20 altitude ranges (~12,000 combinations) to minimize absolute square error predicting on a 33% testing subset
3. Model fit using selected parameters to all altitudes and seasons

Results and Discussion



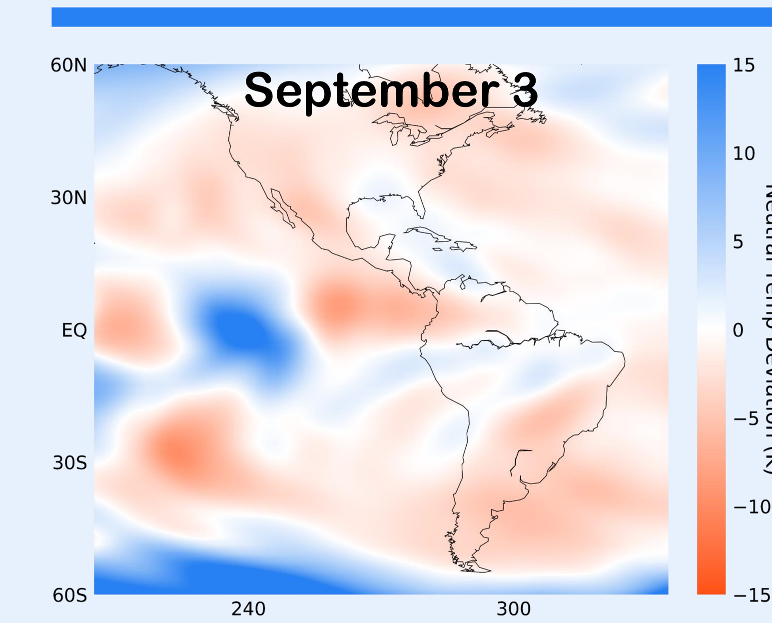




Top: Spline fits using 23 knots and penalization parameter of 0.03 (top two panels). Third panel is the International Reference Ionosphere (IRI) ion temperature (empirical model) using the stated settings. Bottom panel is spline fits for the same season and altitude range but different longitude sectors in the northern hemisphere. **Right**: Northern hemisphere stacked spline fits from 450 to 500 km. Each curve's y-axis ranges from 500-1000K with overlap between them.

- The top two plots are not easily comparable in altitude so fits were stacked on top of each other (right figure) to make qualitative comparisons easier
- Expected MTM behavior can be seen on the right as temperature peaks around -1.5, 0, +1.5 local time which dissipate with height
- The same peaks can be seen in the southern hemisphere for this season however they grow rather than dissipate with height
- Temperature peaks occur higher than expected in all seasons with most becoming prominent at ~430 km
- There is obvious longitudinal variability for the same season and altitude with the American sector showing the strongest MTM signal around midnight
- Differentiating the data into seasons, altitude ranges, hemispheres, and longitude sectors produces nearly 1000 spline fits and thus some quantitative way of comparison is needed to reduce the dimensionality of the problem

Summary and Future Work



- What appears to be the MTM is present around midnight local time in all seasons and longitudes and for most altitudes
- The MTM signal varies greatly with longitude in the same season with the dominating longitude sector varying with hemisphere and season as well

- Fly CNOFS through the Whole Atmosphere Model (left) to compare the resulting curve to the spline fits
- Find quantitative way to compare fits separated by a degree of freedom (altitude, longitude, season, etc..)
- Use dataset with plasma bubbles excluded provided by Gayatri Iyer and Dr. Stoneback from UT Dallas

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Acknowledgements:
NSF AGS 1552078 and AGS 1243129
Dr. Stoneback and Gayatri Iyer of UT Dallas

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