ERWIN-II: Algorithm Description, Wind Results and Meteor Radar

Comparison

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Introduction

The ERWIN-II is a Michelson interferometer that measures the mesospheric wind (∼90 km) by determining the Doppler shift of airglow emissions. Airglow is the emission of light by excited particles in the atmosphere; the airglow emissions of interest are the greenline (557.7 nm) at a height of ∼94 km, and the OH (843.0 nm) at a height of ∼97 km emissions.

ERWIN-II measures five directions simultaneously (north, south, east, west, and zenith) through the use of a quad mirror; this results in an observation cadence of approximately 3 minutes. ERWIN-II is currently located at the PEARL observatory in Eureka, Nu.

Algorithm Description

The ERWIN-II determines the Doppler shift due to the wind by calculating the shift in the Michelson phase. The phase is calculated using a least-mean squares approach that fits the eight raw intensity steps to the Michelson equation:

\[ I(\phi, \bar{a}) = I_0(1 + \chi \cos(\phi + \varphi)), \]

where \( \varphi \) are the Michelson parameters \( I_0 \) (intensity), \( \chi \) (visibility), \( \phi \) (phase step), and \( \varphi \) (background phase). The phase parameters are determined by running an iterative loop until a pre-determined finish condition is met:

\[ \bar{a} = \bar{a}_0 - \frac{\chi^2(d_0)}{\chi^2(d_0) + \chi^2(d_0)} \]

It was discovered that the background phase determined using the calibration lamp differed slightly from that of the emissions, hence the emission background phase from a cloudy day (Jan 28, 2009) was used as the background phase. This results in the intensity and phase images shown in Figure 2. The thermal drift is determined from calibration phase for the greenline, and from the zenith phase for the other emissions; the zero wind is calculated by taking the average of the zenith emission phase over an entire day.

Wind Calculations

The line of sight winds are determined by converting the phase to a wind using

\[ v_{LOS} = \frac{c \Delta \phi}{\Delta \alpha}, \]

where \( \Delta \alpha \) is the effective path difference of the Michelson interferometer, \( \alpha \) is the wavenumber of the emission, and \( c \) is the speed of light. The vertical wind is simply equal to the zenith line of sight wind, and the horizontal winds determined using the line of sight winds taken at an elevation of 38.7° (as shown in figure 3), are

\[ v_1 = \frac{v_{LOS} - \varphi_{LOS} \sin \alpha}{\varphi_{LOS} \cos \alpha} \]

where \( \varphi \) is north, south, east, or west.

The meridional and zonal winds are \( \varphi = \frac{v_1}{v_2} \) and \( v_2 \), respectively.

Conclusion

ERWIN-II is providing reliable wind measurements in the polar region. The relationship between north, south and meridional winds shows that the instrumental results are self-consistent for greenline, more work is required for hydroxyl.

ERWIN and Meteor Radar were shown to have similar results, and an estimate of the height of the emission layers was determined.

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