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Reprocessing of data from Fabry-Perot interferometers (FPI) belonging to the IGP network of optical instruments

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Abstract

IGP network of optical instruments consist of two types of imaging instrumentation: Fabry-Perot Interferometers (FPI) and All-Sky imagers (ASI). The FPI can obtain two dimensional interferograms that are used to study the dynamics of the upper atmosphere. Since the deployment of the first FPI in 1985 and up to the implementation of the FPI network in 2009, which was fully operational in 2011, a processing technique based on Fourier decomposition of the interferogram spectra has been used. An improvement of this technique has been released with a better representation and fitting scheme of the Airy function parameters needed for better estimation of the airglow neutral winds and temperatures. Given that the new processing technique has potentially the ability to generate better products, reprocessing of the IGPs optical data base is being evaluated. First, the two methods need to be compared. In this work we present an analysis of the two methods comparison, showing differences, advantages, and possible improvements to implement.

Introduction

The Fabry-Perot interferometer is an important tool for investigation of the upper atmosphere, providing neutral wind and temperature measurements. Knowledge of these quantities is important to understand the dynamics and coupling between the intermixed neutral and plasma environment of the upper atmosphere. The underlying observing method is based on the Doppler shift and thermal Doppler broadening of naturally occurring night-time airglow emissions in the upper atmosphere. In the case of the FPI network located in Peru, the airglow line under study correspond to the 630 nm OI which are mostly emitted from an altitude of approximately 250 km.

Background

Since the implementation of the interferometer network, scripts written in the IDL language based on Meriwether et al 208 and Makela et al 2011 have been used to process the acquired images from the interferometers. These scripts use a technique based on the Fourier decomposition of the Airy function using the interferogram spectra of laser images acquired over the night. The resultant coefficients followed any thermal instrumental drift along the night, and they were phase-shifted to be used in a second stage to estimate the neutral winds and temperatures from the interferogram spectra of the airglow images recorded along the same night.

In 2013, the work by Harding et al. 2014 updated this processing method to avoid this decomposition and included an improved representation of the Airy function considering optical aberration, intensity decays, etc. These processing scripts were implemented in Python 2.7. This new method shows some advantages compared with the one from 20008 and 2011. Before using the new model, it is important to make a comparison between the two methods.

Comparison between the two methods

In each of these stages the parameters that characterize the instrument are calculated. This is an advantage over the old method, since parameters such as the center of the interferograms are calculated automatically.

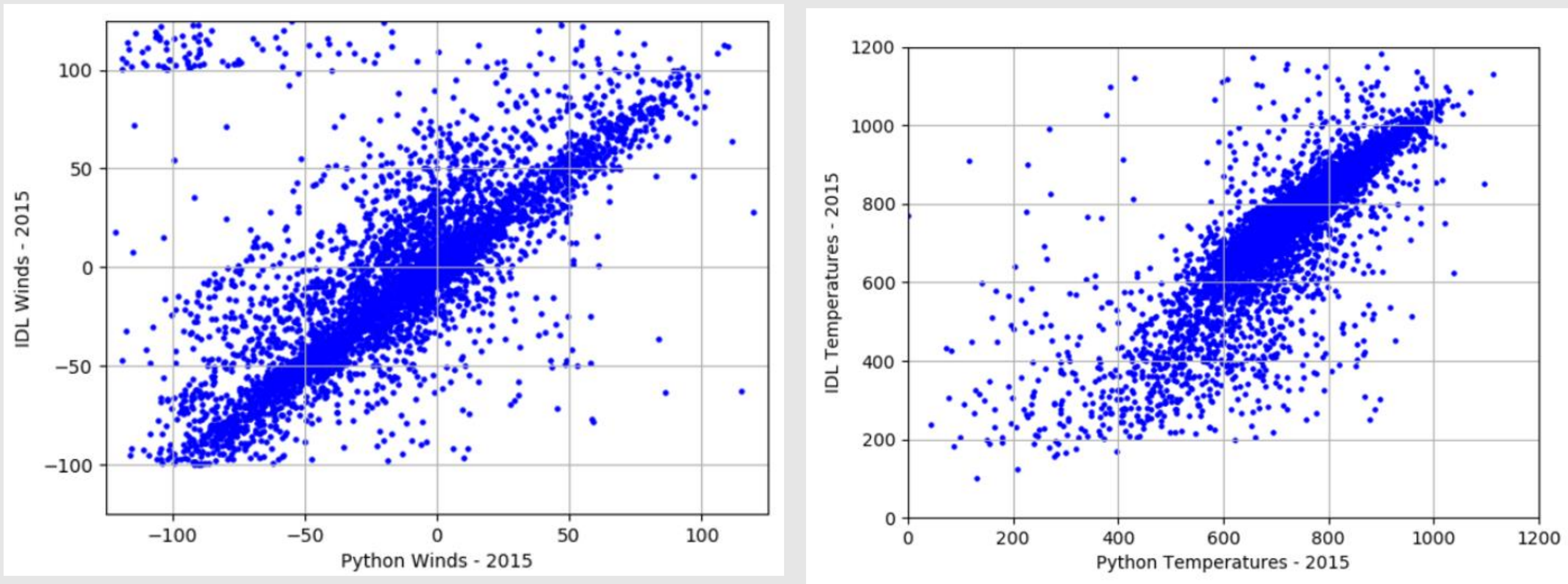

Fig. 1 – Results comparison between both methods. Left (Winds) and right (Temperatures)

To have a numeric comparison between the two methods, a scatter plot was made where the old method results are in the y-axis and the new method results are in the x-axis. The data belongs to measurements made in June 2015. This plot is expected to have a linear form (y= x) if the results of the two methods are similar. Fig. 1 shows that both datasets are very similar, however, there are points that do not follow this trend mostly due to a better fitting scheme of the new method that seems to work better under conditions of low airglow intensity. A similar situation is observed for the right panel of Fig. 1, where the trend is also expected, but has more similarity when the temperature values are higher meaning that old method performs better for higher airglow intensity conditions.

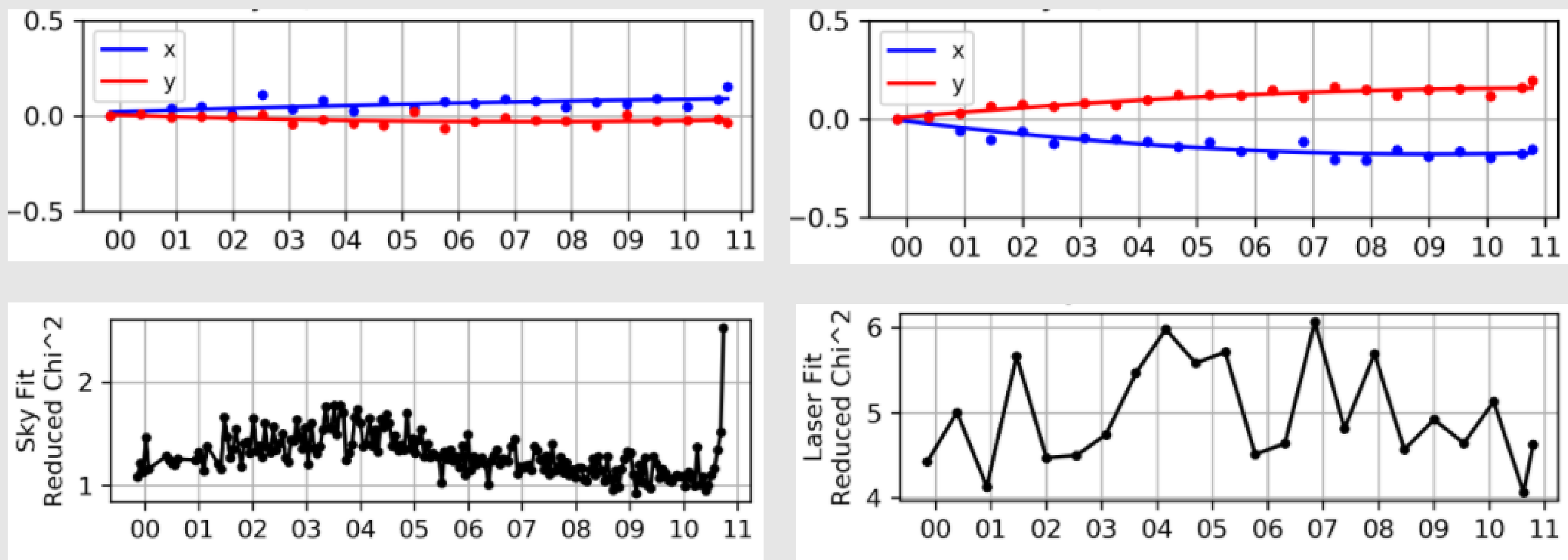

Fig. 2 – Some parameters included in the new processing method for two years: 2019 (right) and 2020 (left). The parameters shown are: Center points of the FPI images (top) and chi-square (bottom).

Another advantage of the new method is that it automatically calculates some parameters such as the center points of the interferograms in contrast to the old method which needs assistance. On the other hand, the graphs of reduced chi square show that the values are close to 1, this indicates that a good model is being fitted.

Conclusions

The new method has several advantages over the old, such as:

- Automatic calculation of X, Y positions
- Better way to diagnose processing failures.
- Automatic selection of FPI images that meet certain standards and automatic discarding of images that were not captured correctly.

Comparing the results of the two methods for this period of time, the tendency of the winds and temperatures are similar. The difference is that the results obtained with the new method seems to have a better handling for lower airglow signal conditions, and so there are less noise or outlier values. With this comparison made, more historical data can be processed to make further analysis of the results.

Acknowledgments

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