Student Graduation Project Proposal Format

Faculty member interested to work with (optional): .....
Department: Physics or Mathematics **Semester/Academic year:** Spring 2020
Industrial sponsor (if any): National Space Science and Technology Center, UAEU
Industrial contact (optional): Dr Roland Young (roland.young@uaeu.ac.ae)

Project Title: Atmospheric turbulence at the InSight landing site on Mars

Introduction

NASA's InSight lander is the first seismology station sent to Mars, where it has been studying the interior structure of the planet since November 2018. In order to interpret possible "marsquakes" and other interior observations correctly, InSight also carries a weather station APSS that measures pressure (APSS-PS) and near-surface winds (APSS-TWINS) at very high time cadence (> 1 Hz). The weather station is a valuable instrument for studying the near-surface Martian atmosphere over many timescales. One aspect of Martian meteorology that is poorly understood is small-scale turbulence, due to very sparse wind measurements. By measuring wind speed and direction at such high frequency, Insight provides a completely unique dataset that can be used to study small-scale turbulence in Mars' atmosphere.

Project Overview

In this project we shall use InSight wind (and possibly surface pressure) measurements to study atmospheric turbulence around the lander. In particular, the turbulent *structure functions* quantify correlations in wind speed and direction between different locations. These can reveal important information about the type of turbulence that occurs in the Martian atmosphere, such as the kinetic energy cascade rate, the direction of energy transfer as a function of length scale, and (with some mathematical manipulation under suitable assumptions) the kinetic energy spectrum.

This type of analysis ideally requires a network or grid of weather stations but it turns out that, when the average wind speed is faster than typical turbulent motions, we can estimate the structure functions from a single measurement station using the so-called "frozen turbulence" hypothesis. Therefore it may be possible to measure these structure functions using the InSight wind data.

Should time permit, we shall compare the results with equivalent diagnostics computed from high-resolution numerical simulations of the lander site.

Specific Objectives

1. Learn how to program in Python, if the student does not know how to do so already.
2. Conduct brief literature review of relevant Mars atmospheric science, InSight instrumentation, and "frozen turbulence".
3. Identify and download relevant InSight data from the NASA Planetary Data System (https://atmos.nmsu.edu/data_and_services/atmospheres_data/INSIGHT/insight.html).
4. Develop software to read in the wind data and display basic summary statistics and/or time series.
5. Develop software to compute the turbulent structure functions and associated turbulence diagnostics from the wind data using the "frozen turbulence" hypothesis.

Relevant preparatory reading

Spiga et al. (2018), "Atmospheric Science with InSight", *Space Science Reviews*, 214, 109, 10.1007/s11214-018-0543-0.

Byrne & Zhang (2013), "Height-dependent transition from 3-D to 2-D turbulence in the hurricane boundary layer", *Geophysical Research Letters*, 40, 1439, 10.1002/grl.50335.

Target student

This project would suit a keen theoretical/computational person in Physics or Mathematics with an interest in exploring Mars' atmosphere using the most recent observations. Past experience with programming would be very helpful.

Project Deliverables

1. Project report
2. 15-minute presentation at a NSSTC Planetary Science group meeting
3. Data processing and analysis code in Python