Assimilation of EMM-Hope and Mars lander observations into high-resolution mesoscale and local models

Dr.Roland Young, +97137136143, roland.young@uaeu.ac.ae

Description

In 2021 the Emirates Mars Mission (EMM-Hope) will begin surveying the Martian atmosphere, to characterize its lower atmosphere on global scales, measure its geographic, diurnal and seasonal variability, and study the interactions between the lower and upper atmosphere.

In this project, we will investigate Mars' lower atmosphere and boundary layer by assimilating data from EMM's thermal infrared instrument EMIRS and from landers and rovers into high-resolution local simulations created using the LMD Mars Mesoscale/Microscale Model, which can be configured as a mesoscale model (MMM) or as a large eddy simulation (LES). Data assimilation is a critical technique in atmospheric science whereby observations are systematically combined with a numerical model to produce complete atmospheric states closer to either model or observations alone. It has been used on Mars with global, low-resolution models for some time, but not yet with high-resolution regional models where the ground topography is well-resolved. This project will first involve adapting an existing Mars data assimilation scheme for the MMM/LES, covering small regions of the planet at high resolution.

EMM's unique orbital geometry will provide periodic blanket coverage of atmospheric parameters such as temperatures and aerosol concentrations. In addition, by the time EMM begins taking data there could be as many as four stations with meteorological instrumentation operating on Mars' surface: NASA's *Curiosity* rover (landed 2012), NASA's *Insight* lander (landed 2018), NASA's *Mars 2020* rover, and ESA/Roscosmos' *ExoMars Kazachok* lander (both launch 2020). This marks the beginnings of a Martian surface meteorological network. The second goal of this project is to combine these surface observations with EMM atmospheric observations using data assimilation, a first for Mars atmospheric science. The high-resolution MMM/LES takes advantage of lander observations by resolving the complex topography surrounding the landers, unresolved in global models, while the surface stations provide high-time resolution observations at single locations. Assimilating data into such models will allow us to investigate many poorly-understood phenomena. Of particular interest is the region to the south and west of Elysium Mons, where the landing sites for *Curiosity*, *Insight*, and *Mars 2020* are located. In this region we can investigate

- The interaction between travelling baroclinic waves and topography, as waves divert southwards around Elysium Mons towards *Insight*, farther south than is normally affected by mid-latitude weather (MMM),
- Slope winds around Elysium Mons, Gale Crater, and across the Martian dichotomy (LES),
- Wind and turbulence around Gale Crater, potentially to back-trace sources of methane and other emissions (LES),

- The phase of the thermal tide, and the diurnal cycle in the boundary layer (MMM),
- Dust lifting from the surface.

This project would suit a keen theoretical/computational person with an interest in exploring Mars' atmosphere using state-of-the-art numerical methods and the most recent observations. The ideal candidate will have taken courses in atmospheric physics and (preferably geophysical) fluid dynamics.

Recommended reading

O. Sharaf et al. (2017) "Emirates Mars Mission (EMM) Overview", *Sixth International Workshop on the Mars Atmosphere, Granada, Spain, 17-20 January 2017*.

T. Navarro et al. (2017) "The challenge of atmospheric data assimilation on Mars", *Earth Space Sci.*, 4, 690-722, 10.1002/2017EA000274.

A. Spiga et al. (2010) "Structure and dynamics of the convective boundary layer on Mars as inferred from large-eddy simulations and remote-sensing measurements", *Q. J. Roy. Meteorol. Soc.,* 136, 414-428, 10.1002/qj.563.

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

Candidate Profile

Masters in Physics, Mathematics, or similar.