GLOBAL AND LOCAL CLIMATOLOGY OF MARS AND ITS DUST CYCLE FROM ASSIMILATION OF SPACECRAFT OBSERVATIONS. P. L. Read[1], A. Valeanu[1], Tao Ruan[1], R. M. B Young[1] and S. R. Lewis[3], [1]University of Oxford, UK (Atmospheric, Oceanic & Planetary Physics, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, UK; peter.read@physics.ox.ac.uk), [2]The Open University, UK(S.R.Lewis@open.ac.uk)

Introduction: The atmosphere and near-surface environment of Mars exhibits a highly dynamic climate and circulation on all space and time scales. Remote sensing observations of variables such as atmospheric and surface temperature, cloud aerosol and dust opacity provide information with global coverage and moderate resolution in space and time, but cannot resolve variations on horizontal scales < 100 km or close to the surface. In situ instrumentation on lander spacecraft provide much local detail, but lack the broader meteorological context. Both sources of data are fundemantally incomplete, however, since certain variables, such as surface pressure or vertical velocity, are difficult or impossible to derive directly from the measurements.

An alternative approach to the determination of the Martian climate has emergd recently with the application of meteorological data assimilation methods. Such an approach builds on techniques originally developed by the Earth meteorology and climate community, and seeks to combine sets of incomplete and noisy observations with comprehensive numerical simulations of the Martian atmospheric circulation and near-surface environment. The model simulation is typically constrained to evolve its atmospheric state to remain statistically consistent with available observations to within reasonable uncertainties.

Several groups in Europe and USA have recently deployed this approach successfully, using data from infrared sounding instrumentation on NASA's Mars Global Surveyor (MGS) and Mars Reconnaissance Orbiter (MRO) spacecraft[1,2]. The results demonstrate the ablity of assimilation to capture accurately the day by day meteorological variability of the Martian meteorology, at least on large "synoptic" scales, allowing the compilation of a global climatology for Mars covering a number of Mars years. This has even led to the publication of a publicly accessible climae record for the whole of Mars, known as MACDA[3]. This approach is now being extended in Oxford and at the Open University in the UK to cover dust and water ice[4,5], and to utilize a limited area numerical model at mesoscale resolution to recover local meteorology at locations such as near the Curiosity Rover in Gale Crater.

Dust Cycle: Dust storms and other processes lifting dust into the atmosphere are a major source of atmospheric variability on Mars at certain seasons of the year. The atmospheric dust loading is highly variable and needs to be taken into account in compiling an accurate climate record. Observations of dust opacity have been obtained from Mars orbit by infrared instruments on MGS, MRO and Mars Odyssey (MO). In recent work at Oxford, we have extended our earlier Analysis Correction assimilation scheme to include dust column opacity and limb profile measurements from the THEMIS instrument on MO and the Mars Climate Sounder (MCS) on MRO in assimilations using a global numerical model with an active dust cycle. Results from this approach will be presented that demonstrate sn ability to reconstruct the life cycles of regional scale dust storms on Mars. Assimilated data compare well with in situ measurements of column dust opacity above the Spirit and Opportunity Rover sites during several Mars years. This approach is now being extended to cover most of the data records obtained by MRO and forthcoming from ESA's Trace Gas Orbiter.

Mesoscale downscaling: Global numerical circulation models are limited in the spatial resolution they can bring to bear on climatological assimilations, because of their high computational cost. Even the highest resolution global models that have been depooyed so far (with horizontal resolution $\leq 1^{\circ}$ in latitude or longitude) are unable to resolve topographic features such as Gale Crater. This leads to major systematic errors e.g. in surface pressure between model simulations and in situ observations, reducing the utility of assimilated datasets in the vicinity of sharp topographic variability.

In new work, however, we have deployed a limited area mesoscale model, embedded within a global assimilation, to reconstruct the detailed meteorology in the vicinity of the Curiosity Rover. Results compare favourably with REMS measurements from Curiosity, providing both a detailed climatology and larger scale context for phenomena measured by Curoisity. Presliminary results using this approach will be presented and discussed, with a view to further deployment of this approach e.g. for evaluation of the climatology of landing sites proposed for future Mars missions.

References: [1] Lewis, S. R. et al. (2007) *Icarus, 192,* 327–347. [2] S. J. Greybush et al. (2012) *JGR,* *117*, E11008. [3] Montabone, L. et al. (2014) *Geosci. Mod. Dev., 1*, 129–139.