The Case for InSAR at Venus

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Cosmic Vision aims to explore the formation of planets and to search for life. Venus Express is still harvesting a wealth of data about the atmosphere of Venus but, unlike Mars Express, has only a limited capability of providing surface images, in the infrared. Atmospheric studies have lent some support to the possibility of present-day volcanic activity but there is no direct evidence. In the global chemistry cycle, geological activity is the critical link between the crust and interior of the planet and its atmosphere, providing a long-term source and sink for reactive volatiles and potentially recycling them through volcano-tectonic processes. The nature of geological activity on Venus remains hotly contested, between models involving a past catastrophic resurfacing event and relative quiescence at present; models involving a monotonic decline in activity; through to models that imply a relatively active surface at the present day. Unfortunately, Magellan SAR data are sufficiently ambiguous and contradictory that a universally accepted interpretation is unlikely.

Apart from some of the more ambitious VEXAG concepts, currently proposed Venus missions will not address this important question, focussing instead on direct atmospheric measurements. The European Venus Explorer (EVE) will embark a small (7 kg, 9 watt) ground-penetrating radar (GPR) on the Orbiter, to explore surface structures to 300 m depth. From Magellan data, Maat Mons is the most likely candidate for present day volcanic activity [1], while some of the rift and coronae systems, e.g., Diana Chasma, are likely to have active faults, and an active mountain belt is inferred in south east Thetis Regio [2]. An interferometric SAR (InSAR) system is capable of detecting the small changes in surface elevation associated with magmatic inflation and fault movements (earthquakes) and would therefore be able to address the question of whether these and other features are geologically active and, if so, by how much. Geological activity is often inferred on the basis of its association with fine impact ejecta deposits which are only slowly removed by aeolian processes [3], which are only significant in the highlands [4]; InSAR could constrain the rate of removal of these deposits and aeolian activity rates in the highlands, thereby helping to date a number of surface features.

Interferograms were successfully generated during the Magellan mission from data acquired at least 7 hours apart, in an unpublished study to determine the position of the north pole. Since then, InSAR techniques have progressed enormously, particularly in Europe (thanks to ERS and Envisat), such that long-term repeated InSAR observations are now routinely used to detect small changes (< 1 mm a^{-1}) arising from earthquake deformation, subsidence and volcanic activity. The mainly low rates of erosion and sedimentation and lack of lower atmospheric weather make Venus more favourable to InSAR observations than Earth, especially if the orbit can be circularised to make observations more frequently and with a more uniform imaging geometry.

We therefore propose to explore how the EVE programme might include InSAR for long-term repeat imaging of the surface. At the end of the balloon mission EVE's orbit would be circularised by aerobraking and an initial data-intensive phase would collect data from candidate regions. Whether or not movement is detected in these data will answer the question of present activity on Venus and profoundly influence our understanding of our nearest planetary neighbour. Addressing this important question, by the inclusion of an InSAR system, will significantly increase the science return of EVE, further enhancing the case for its funding.

[1] Glaze, 1999, *JGR*, 104, 18899. [2] Ghail, 2002, *JGR*, 107, 5060. [3] Bondarenko & Head, 2004, *JGR*, 109, E09004. [4] Campbell *et al.*, 1999, *JGR*, 104, 1897