A1. Summary of key monitoring observables at Soufrière Hills Volcano

1. Seismicity

A small seismic network was in place at SHV prior to the onset of eruptive activity in 1995. As eruptive activity developed the seismic network has evolved with more instruments added and a transition from analogue to broadband seismometers (Miller et al., 1998; Neuberg et al., 1998; Luckett et al., 2007). Distinctive waveforms are associated with different styles of eruptive activity (Miller et al., 1998): low frequency (long-period: LP) and hybrid seismicity is mostly associated with dome growth (Wadge et al., 2014). High frequency volcano-tectonic events (VT), which were very numerous before and during the commencement of the eruption, have typically occurred in swarms prior to the renewal of eruptive activity, as well as being associated with ash venting and gas fluxing events during eruptive pauses (Cole et al., 2014; Christopher et al., 2015). In general, the seismic event rate (rate or count of volcanic-seismic events) is well correlated with eruptive activity (Fig. 3 in main text - top). However, there has been a marked decrease in overall seismicity, of all types, since the start of the eruption, which is interpreted to represent the evolution of the SHV eruptive system and changing internal conditions (Wadge et al., 2014).

2. Deformation

Deformation of the volcanic edifice of SHV has been measured using a variety of techniques including GPS monitoring, Electronic Distance Measurements (EDM), tilt measurements, strain measurements, gravity surveys and remote sensing techniques (Odbert et al., 2014). Far-field cGPS monitoring (> 5 km from the volcano) provides the longest record of deformation, and has been continuously in place since 1998. In general, island-scale deformation exhibits an overall 'saw tooth' pattern (inflation/deflation trends of the MVO cGPS network, usually expressed as a radial rate from the centroid of the volcano) with inflation during pauses in eruptive activity and deflation corresponding with periods of lava extrusion (Fig. 2 - middle) (Odbert et al., 2014; Wadge et al., 2014). These observations have been inverted using analytical and numerical models to infer upper and mid-crustal regions of magma storage and transfer below SHV (Elsworth et al., 2008; Hautmann et al., 2010; Gottsmann and Odbert, 2014; Hautmann et al., 2014).

3. Degassing

Near-continuous monitoring of SO_2 fluxes (in tonnes per day) has been performed at SHV since 1996 (Fig. 2 - bottom). For the first seven years, campaign measurements were made using correlation spectroscopy (COSPEC) and, since 2002, a permanent network has been installed employing Differential Optical Absorption Spectroscopy (DOAS) instruments (Edmonds et al., 2003; Christopher et al., 2010). At SHV, changes in SO_2 flux appears to have been decoupled from the eruption of magma (Christopher et al., 2015) and prior to 2010, the volcano exhibited a weak two-year periodicity in the pattern of degassing (Christopher et al., 2014a). Following the partial dome-collapse event in February 2010, there has been no eruptive activity but sustained, stable fluxes of SO_2 around 430 t/d (Christopher et al., 2015). In this latter period, transient peaks in SO_2 fluxes have occurred concurrently with brief swarms of VT earthquakes and ash-venting events, attributed to the accumulation of magmatic gases or fluids in the shallow magmatic system and formation of relatively low but positive overpressures (Hautmann et al., 2014; Christopher et al., 2015).

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A2. Statistical methods and elicitation questions

Expert elicitation methodology

We use the Classical Model formulation (Cooke, 1991; Aspinall and Cooke, 2013) implemented using the EXCALIBUR software package (v.1 pro; Cooke and Solomatine, 1992). Participating experts are scored according to a joint measure of their informativeness and statistical accuracy, based on their responses to a set of *seed items* that are relevant to the topic at hand (e.g., volcanic unrest and patterns of volcanism). Values for the *seed questions* are known only by the facilitator and experts are not expected to know these precisely, but they are expected to capture them dependably within their own expressed credible intervals, across the set of *seed items*. The initial hypothesis of the Classical Model is that the experts in a group are presumed equally good at providing medians and credible interval quantiles, until their capabilities are measured statistically, via performance on the set of *seed items*.

For each *seed item* experts are asked to provide a median value and the bounds of a 90% credible interval that they judge would include the true value, were they to discover it post hoc. *Calibration weights* are derived for each expert and reflect their ability to accurately capture the realisation values in the seed questions via the statistical hypothesis test, and to give informative expression to the associated uncertainties when doing so. It is the objective measurement of this calibration procedure that, uniquely amongst elicitation procedures, provides the Classical Model with its empirical control in differentially weighting experts' judgments (Aspinall, 2010).

The resulting calibration score represents a measure of the experts' skills as judges of uncertain information. As all experts had been calibrated prior to this study for previous SAC meetings, so those findings are not presented here. Once experts are calibrated they can be asked a series of *target questions* related to the problem that is being investigated (Supplementary material). As with the *seed items*, they are asked to provide a 3-value distribution (5th, 50th, 95th percentile values) for each target item in order to quantify their uncertainty belief. The target questions must be carefully identified to address the needs of the model, while maximising the experts' ability to apply scientific judgement to their responses. The responses from all experts for each target question are weighted and pooled according to their calibration scores to give a distribution that represents the weighted combined view of the group. This is referred to as the optimised Decision-Maker (DM) distribution.

Probabilistic inversion methodology

When there is insufficient data to distinguish between factors or processes as causes, it is still usually possible to get experts to rank a pair of alternatives to indicate which, depending on the context and framing of the comparison, is considered more likely, more critical or more important than the other. For a set of several factors, the 'pairwise comparison' elicitation process involves participants selecting all factors two-by-two and indicating which of each pair they judge ranks higher. The sets of responses of individual experts and of the group as a whole can then be tested against the statistical hypothesis that the resulting pairwise preferences were not randomly chosen. To do this, responses are analysed across and within the expert group using the software tool UNIBALANCE (Macutkiewicz and Cooke, 2006), which has a probabilistic inversion algorithm for constructing a factor ranking preference order from the various input choices, with associated estimates of variance on rank scores.

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SAC 18: Soufrière Hills Volcano BBN analysis

Target questions for uncertainty quantification (UQ)

<u>Please state your probabilities as %ages (converting from decimal probs or odds, if necessary - e.g. if Pr=0.0001 or 1-in-10,000, this equates to 0.01%)</u>

<u>For each table, the median values have to sum to one</u>

- Based upon the evolution of eruptive activity since the onset of activity in 1995, what is the probability that the trend in activity is:

	Lower (5%ile)	Median	High (95%ile)
1. Escalating			
2. Consistent			
3. Diminishing			

Given the trend in eruption activity is escalating, what is the probability SHV is in a persistent regime?

	Lower (5%ile)	Median	High (95%ile)
4. Pr(Persistent|Escalating)			

- Given the trend in eruption activity is consistent, what is the probability SHV is in a persistent regime?

	Lower (5%ile)	Median	High (95%ile)
5. Pr(Persistent|Consistent)			

- Given the trend in eruption activity is diminishing, what is the probability SHIV is in a persistent regime?

	Lower (5%ile)	Median	High (95%ile)
6. Pr(Persistent|Diminishing)			

- What is the probability that SHV is in a persistent regime (as opposed to a episodic regime) given current levels of degassing?

	Lower (5%ile)	Median	High (95%ile)
7. Pr(Persistent|Degassing)			

- Assuming activity at SHV is in a persistent regime, what is the probability of observing the current period of quiescence (over 3 years) accompanied by the observed degassing?

	Lower (5%ile)	Median	High (95%ile)
8. Pr(Degassing|Persistent)			

- Assuming activity at SHV is now in an episodic regime, what is the probability of observing the current period of quiescence (over 3 years) accompanied by the observed degassing?

	Lower (5%ile)	Median	High (95%ile)
9. Pr(Degassing|Episodic)			

- Given SHV has been active for 18 years and will erupt in less than one year from now (T < 1), what is the probability that the Reservoir Eruption Potential (REP) is currently increasing?

	Lower (5%ile)	Median	High (95%ile)
10. Pr(I-REP|T<1)			

- Given SHV has been active for 18 years and will erupt between one and five years from now (1 <= T < 5), what is the probability that the Reservoir Eruption Potential (REP) is currently increasing?

	Lower (5%ile)	Median	High (95%ile)
11. Pr(I-REP|1<=T<5)			

- Given SHV has been active for 18 years and will erupt between five and thirty years from now (5 <= T < 30), what is the probability that the Reservoir Eruption Potential (REP) is currently increasing?

	Lower (5%ile)	Median	High (95%ile)
12. Pr(I-REP|5<=T<30)			

- Given SHV has been active for 18 years and will **not** erupt in the next thirty years (T >= 30), what is the probability that the Reservoir Eruption Potential (REP) is currently increasing?

	Lower (5%ile)	Median	High (95%ile)
13. Pr(I-REP|T>=30)			

- What is the probability that the REP is increasing given current observations of cGPS?

	Lower (5%ile)	Median	High (95%ile)
14. Pr(I-REP|cGPS)			

- What is the probability that the REP is increasing given current observations of seismicity?

	Lower (5%ile)	Median	High (95%ile)
15. Pr(I-REP|Seismicity)			

- What is the probability that the REP is increasing given current patterns of SO_2 emissions?

	Lower (5%ile)	Median	High (95%ile)
16. Pr(I-REP|SO_2)			

- Given SHV is in a persistent regime, what is the probability of quiescence lasting (in years):

	Lower (5%ile)	Median	High (95%ile)
17. T < 1			
18. 1 <= T < 5			
19. 5 <= T < 30			
20. T >= 30			

- Given SHV is in a episodic regime, what is the probability of quiescence lasting (in years):

	Lower (5%ile)	Median	High (95%ile)
21. T < 1			
22. 1 <= T < 5			
23. 5 <= T < 30			
24. T >= 30			

Re-eliciting questions

Due to some discrepancies in the numbers produced for certain questions we have decided that it would be good to re-elicit them. The first four pairs of questions (25&26, 27&28, 29&30, 31&32) are mutually exclusive so median values should sum to 100%.

Questions 25, 27 & 29 are the same as questions that were elicited at the SAC and we have decided to re-elicit them as there is a wide spread in the answers for these questions. Also, there was clearly some confusion with these questions (from listening back to the discussion at the SAC meeting) and so we have decided to ask the complementary questions too (26, 28 & 30).

Questions 33 & 34 are once again directly from the elicitation performed at the SAC. The reasoning for eliciting these questions (along with question 31 and the complementary question 32) is that there were two distinct schools of thought with regard to the probability of observing the degassing trend over this current pause given the two eruptive regimes. We would like to check whether this is the case, as this will influence the belief of the eruptive regime (i.e. episodic or persistent).

As usual, please put probabilities as percentages.

25. Given the trend in eruptive activity at SHV is **escalating**, what is the probability that it is in a **persistent** regime?

26. Given the trend in eruptive activity at SHV is **escalating**, what is the probability that it is in a **episodic** regime?

	Lower (5%ile)	Median	Higher (95%ile)
25			
26			

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27. Given the trend in eruptive activity at SHV is **consistent**, what is the probability that it is in a **persistent** regime?

28. Given the trend in eruptive activity at SHV is **consistent**, what is the probability that it is in a **episodic** regime?

	Lower (5%ile)	Median	Higher (95%ile)

27			
28			

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29. Given the trend in eruptive activity at SHV is **diminishing**, what is the probability that it is in a **persistent** regime?

30. Given the trend in eruptive activity at SHV is **diminishing**, what is the probability that it is in a **episodic** regime?

	Lower (5%ile)	Median	Higher (95%ile)
29			
30			

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31. What is the probability that SHV is in a **persistent** regime given current levels of degassing at SHV?

32. What is the probability that SHV is in a **episodic** regime given current levels of degassing at SHV?

	Lower (5%ile)	Median	Higher (95%ile)
31			
32			

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33. **Assuming** SHV is in a **persistent** regime, what is the probability of observing the current period of quiescence (over 3 years) accompanied by the observed degassing?

	Lower (5%ile)	Median	Higher (95%ile)
33			

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34. **Assuming** SHV is in a **episodic** regime, what is the probability of observing the current period of quiescence (over 3 years) accompanied by the observed degassing?

	Lower (5%ile)	Median	Higher (95%ile)
34			
