The rotational spectra of three isotopologues of H$_2$S···ICF$_3$ and four isotopologues of H$_2$O···ICF$_3$ have been measured between 7 and 18.5 GHz by chirped-pulse Fourier transform microwave spectroscopy. The rotational constant, $B_0$, the centrifugal distortion constants, $D_J$ and $D_{JK}$, and the nuclear quadrupole coupling constant of $^{127}$I, $\chi_{aa}(I)$, are precisely determined for H$_2$S···ICF$_3$ and H$_2$O···ICF$_3$ by fitting observed transitions to the Hamiltonians appropriate to symmetric tops. The measured rotational constants allow determination of the molecular geometries. The $C_2$ axis of H$_2$O / H$_2$S intersects the $C_3$ axis of the CF$_3$I sub-unit at the oxygen atom. The $r_0$ lengths of halogen bonds identified between iodine and sulphur, $r(S···I)$, and iodine and oxygen, $r(O···I)$, are determined to be 3.5589(2) Å and 3.0517(18) Å respectively. The angle, $\phi$, between the local $C_2$ axis of the H$_2$S / H$_2$O sub-unit and the $C_3$ axis of CF$_3$I is found to be 93.7(2)$^\circ$ in H$_2$S···ICF$_3$ and 34.4(20)$^\circ$ in H$_2$O···ICF$_3$. The observed symmetric top spectra imply nearly free internal precession of the $C_2$ axis of the hydrogen sulphide/water unit about the $C_3$ axis of CF$_3$I in each of these complexes. Additional transitions of H$_2^{16}$O···ICF$_3$, D$_2^{16}$O···ICF$_3$ and H$_2^{18}$O···ICF$_3$ can only be assigned using Hamiltonians appropriate to asymmetric tops, suggesting that the effective rigid-rotor fits employed do not completely represent the internal dynamics of H$_2$O···ICF$_3$. 