Simulation-regression based interpretation of particle sensor measurements

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The most basic space plasma parameters, including density, temperature, ion mass composition, and plasma flow velocity are generally inferred from low level (L1B) sensor measurements interpreted on the basis of analytic expressions derived from theoretical models. These expressions have the advantage of being sufficiently simple to be implemented in fast algorithms applicable in real-time operation mode. However the simplifications made in these models, imply that several physical processes cannot be accounted for in the inference of physical parameters from low level measurements, which in turn can result in significant uncertainties. Additionally, the inference of a parameter as, for example, the density, generally relies on other parameter, as the ion mass composition, the plasma flow velocity, and spacecraft floating potential. That is, it is typically not practical to measure one plasma parameter independently of others and an optimal interpretation of sensor measurements should generally require the simultaneous interpretation of several complementary measurements. An approach is presented to overcome the limitations of interpretative algorithms based on analytic models, by using advanced three-dimensional multi-physics computer simulations capable of accounting for more realistic conditions and processes than possible with analytic theories. Owing to the large computational resources and simulation times required however, such simulations are not practical in real time operation mode. The proposed approach is to construct solution libraries obtained from simulations made for representative space plasma conditions, combined with multivariate regression techniques, to interpret multi-sensor measurements in terms of physical parameters of interest. Results from two such approaches, consisting of Radial Basis Functions (RBF) and Neural Networks (NN) are presentedfor a simple flow meter, and a segmented spherical Langmuir probe, under representative space plasma environment conditions.