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An extended global study of hot flow anomalies using Cluster multi-spacecraft measurements

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Discovered nearly 20 years ago near the Earth's bow shock, the identification of Hot Flow Anomalies (HFAs) and their separation from other events is still under debate. Hot flow anomalies are studied using observations of the RAPID suprathermal charged particle detector, the FGM magnetometer, and the CIS plasma detector aboard the four Cluster spacecraft. We studied previously several specific features of tangential discontinuities on the basis of Cluster measurements in February-April 2003 when their separation was large and discovered a new condition for forming HFAs, that is the solar wind speed and so its kinetic pressure is higher than the average. The existence of this new condition was also confirmed by simultaneous ACE MAG and SWEPAM solar wind observations at the L1 point 1.4 million km far from the Earth. This new condition was further examined here using data from recent spring periods in 2006 when the Cluster fleet stayed right outside of the bow shock at varying separation distances. The total energy amount of HFA events was also estimated; the energetic features were particularly examined and finally compared previous numerical simulations. Geometrical description of the bulge was performed using triangular techniques for Cluster FGM measurements of bow shock crossing. A new theory of HFA formation was constructed to explain the newly discovered fast solar wind velocity condition. Both spring periods in 2003 and 2006 were compared to previous hybrid simulations and the newly developed theory.