Due to unbounded input operators in partial differential equations (PDEs) with boundary inputs, there has been a long-held intuition that input-to-state stability (ISS) properties and finite gains cannot be established with respect to disturbances at the boundary. This intuition has been reinforced by many unsuccessful attempts, as well as by the success in establishing ISS only with respect to the derivative of the disturbance. Contrary to this intuition, we establish such a result for parabolic PDEs. Our methodology does not rely on the transformation of the boundary disturbance to a distributed input and the stability analysis is performed in time-varying subsets of the state space. The obtained results are used for the comparison of the gain coefficients of transport PDEs with respect to inlet disturbances and for the establishment of the ISS property with respect to control actuator errors for parabolic systems under boundary feedback control.