**Reference Frames**

Ascending-descending accelerometry (ADA) analyzes *in-track* accelerations in the satellite body frame (SBF)

A diagram of a flying object

Description automatically generated

Accelerometer Data

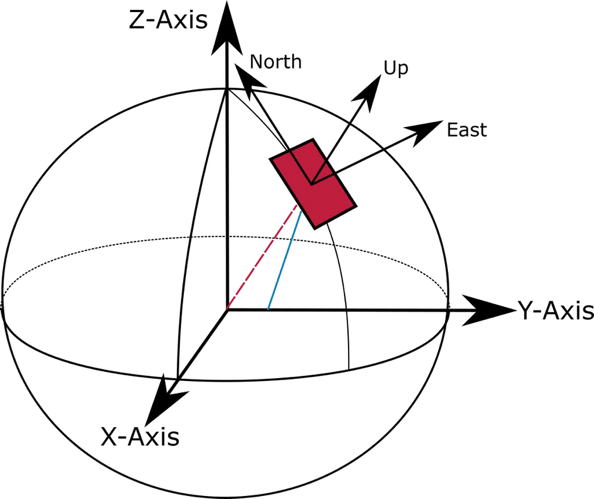
A black text on a white background

Description automatically generated

x = in-track; y = cross-track; z = vertical

**Figure 1:** CHAMP Satellite Body Frame (SBF)

Relevant atmospheric motion are thermospheric winds, which are organized in local coordinates (East, North, Up) in addition to co-rotating atmospheric winds



Thermospheric Winds

**A black text with arrows and symbols

Description automatically generated with medium confidence**

u=zonal, v=meridional, w=vertical

**A black text on a white background

Description automatically generated**

**A black text on a white background

Description automatically generated**

λ= geographic latitude

**Figure 2:** Thermospheric wind organization in

the East-North-Up (ENU) frame

**A circle diagram with numbers and a circle with a line

Description automatically generated with medium confidence**

**Figure 3:** Organization of ascending (a) and descending (b) passes from the perspective of the north pole. Q1 = early morning sector, Q2-Q3 is the dayside sector, and Q4 is the premidnight sector.

**Relevant Equations and Definitions**

Expansion of the In-Track Drag Acceleration

A globe with a black circle and red lines

Description automatically generated

* Inverse Ballistic Coefficient
* Angle between the in-track direction and the meridian
* Satellite velocity with respect to the co-rotating atmosphere

* + - * Satellite velocity (aligned with in-track for CHAMP)

* + - * Co-rotating atmospheric winds

* + - * Neutral winds

Background acceleration

* are the background inverse ballistic coefficient and mass density, respectively. These will not be computed directly.
* is the background satellite velocity with respect to the co-rotating atmosphere. This can be estimated as , where is estimated using a model.

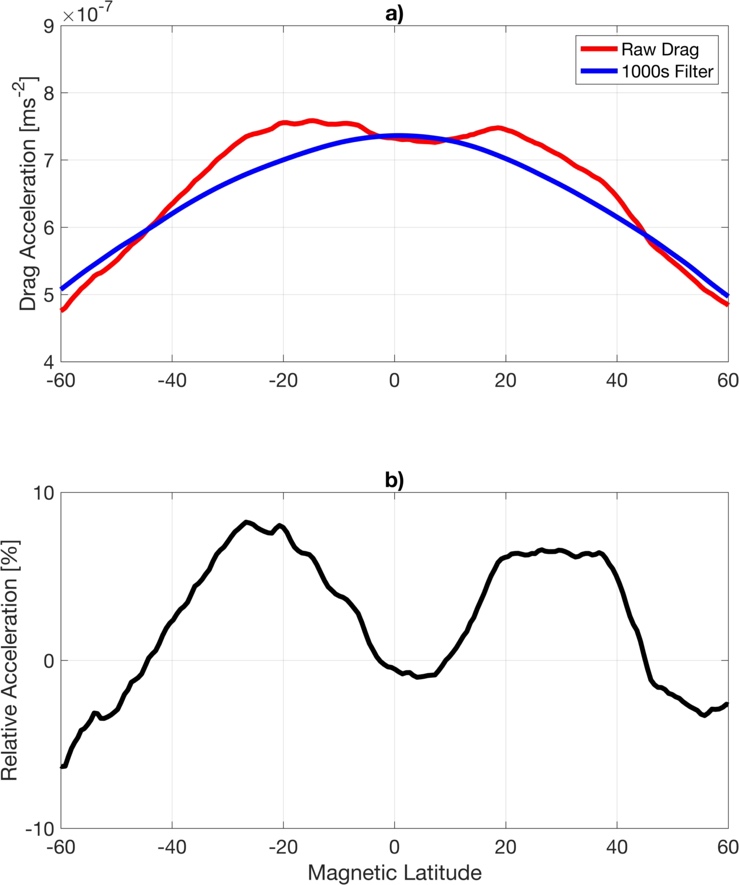
Linearization of the in-track drag acceleration



This equation is the basis for observing how perturbations in mass density, inverse ballistic coefficient, and velocity affect the relative acceleration. The following page describes how can be computed empirically.

Computing empirically

* is the in-track accelerometer data normalized to a constant altitude, h
* is the normalized in-track accelerometer filtered using a moving average filter corresponding to the desired scale length



**Figure:** Example of deriving the relative acceleration empirically. (a) raw and 1000s filtered accelerometer measurements with respect to magnetic latitude at the equatorial dayside for a single orbit and (b) relative acceleration.

Deriving the density-wind dominance indicator for ADA

* Density-dominated (i.e., )

Here, the assumption is that ascending and descending relative acceleration accelerations are equal if only considering mass density perturbations over a region.

= 0

Density-dominated condition

* Wind-dominated (i.e., )

Here, the assumption is that changes in the velocity between ascending and descending passes are solely due to wind, given that the satellite velocity is constant.

* + - * Assume

A diagram of a line

Description automatically generated

The meridional wind component is responsible for changes between ascending and descending.

Implies

Wind-dominated condition

* Density-Wind Dominance Indicator (
  + - * indicates density-dominance
      * indicates wind-dominance

Deriving the in-track wind extraction for ADA

* + - * (+) are northward winds
      * (-) are southward winds