Correction of occultation patterns based on tangential altitude

IED 18 Dec 2014

First, one has to consider that LYRA occultation patterns are asymmetrical: Obviously, there is a difference whether the observed irradiance is ascending (PROBA2 moves from the Earth shadow into brightness) or descending (PROBA2 moves from unhindered full disk observation into the Earth's atmosphere). A physical explanation is still TBD. Candidates are instrument artifacts (e.g., slower reaction of MSM detectors) or atmospheric asymmetries (e.g., day/night).

Second, one has to consider daily variations in the irradiance level. The first attempt to construct an average profile failed due to these level differences - the variance was too big, the results were too noisy. The only solution was to scale the occultation profiles to [0,1]. This was done by following the ascending profiles, minute by minute, starting with the beginning of the day, and scaling them by subtracting the minimum and dividing by the resulting maximum of the single ascending profile. Then, the same was done by following the descending profiles, minute by minute, starting with the end of the day, and scaling them likewise. (Of course, to be exact, this works only for complete profiles.) Taking the median of three days, i.e. approx 3x14 ascending and 3x14 descending profiles, and calculating a moving average for 108 different altitudes, results in daily profiles which show little noise and are thus comparable. The average irradiance is measured around tangential altitudes [-350km, -340km, ... , 0km, ... , +710km, +720km] in intervals covering +/-25km. For ch2-4 as an example, see Figure 1.

151 days between 01 Oct 2013 and 28 Feb 2014 are taken into account. As a result, one can confirm that within the interval of complete profiles (approx day 35 to 120), they actually stay constant when scaled. In other words, the functional relationship between tangential altitude and resulting relative irradiance is unique and not influenced by the daily activity level. It is influenced, though, by the fact whether the profile is ascending or descending. And it is influenced by the year of the occultation season, because the spectral degradation may change the profile structure, as one could see in the case of Lyman-alpha channel 2-1. For the resulting average profiles, see Figure 2.

With information about the daily level of irradiance, one can reconstruct a theoretical occultation profile and thus correct the observed profile. According to first tests, this appears to work in most of the cases (except some early and late days in the season, where the method over-compensates, and which can be simply remain uncorrected), for tangential altitudes down to 100km (ch2-1, ch2-2) or 250km (ch2-3, ch2-4). For lower altitudes, there has to remain a gap. Examples are enclosed for day 65 of the last season (05 Dec 2013), see Figure 3 a,b,c,d.

To generalize this method, all occultation seasons should be analyzed, the tangential altitude must be known in 1-minute resolution, and the daily irradiance level has to be known. To estimate the correction for the running day, the level for the last day can be taken as a temporary substitute.

For ch2-4 (at least) there remains an unexplained small pattern “above” the atmosphere, i.e. at tangential altitudes which are artificially set to “1000km”.

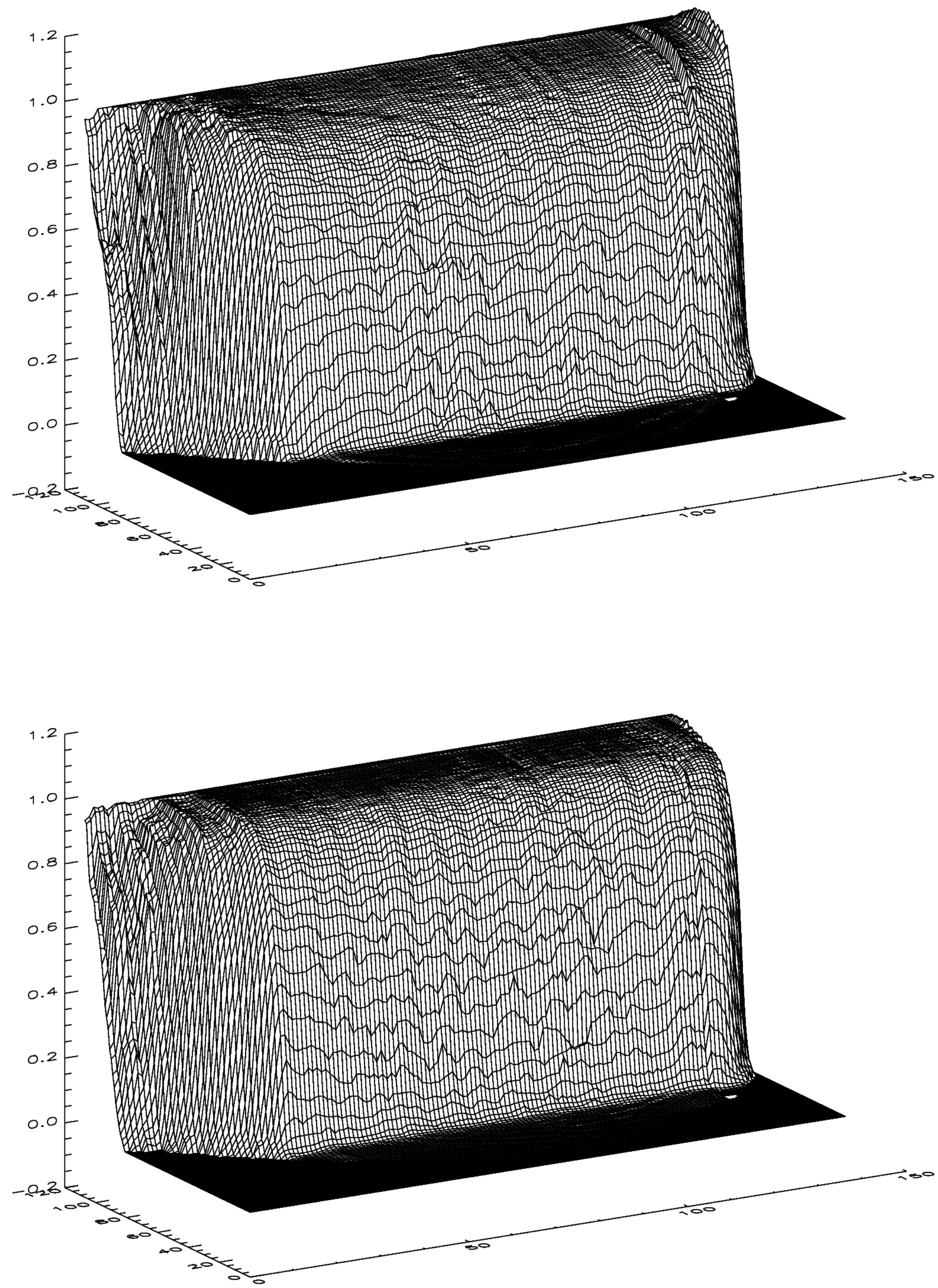
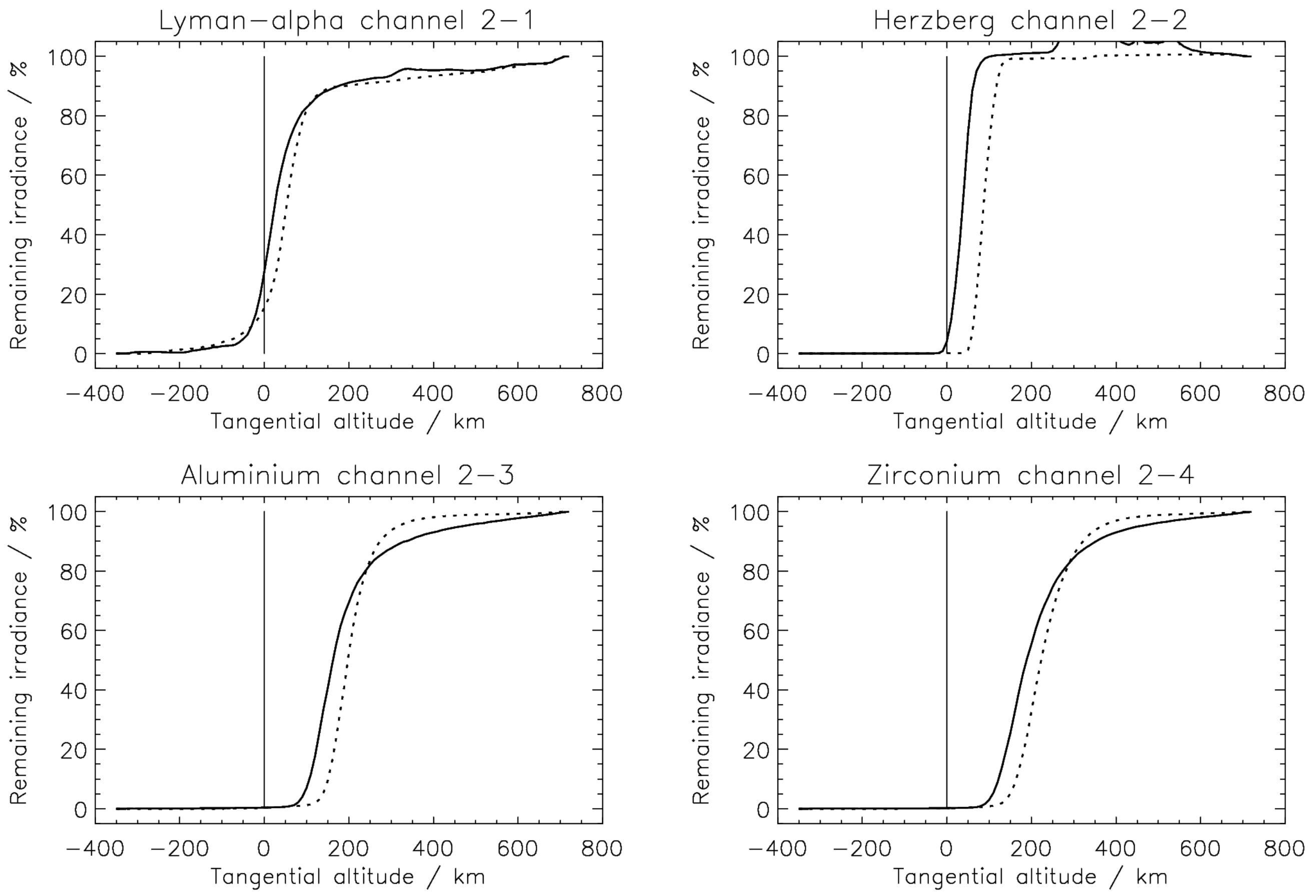
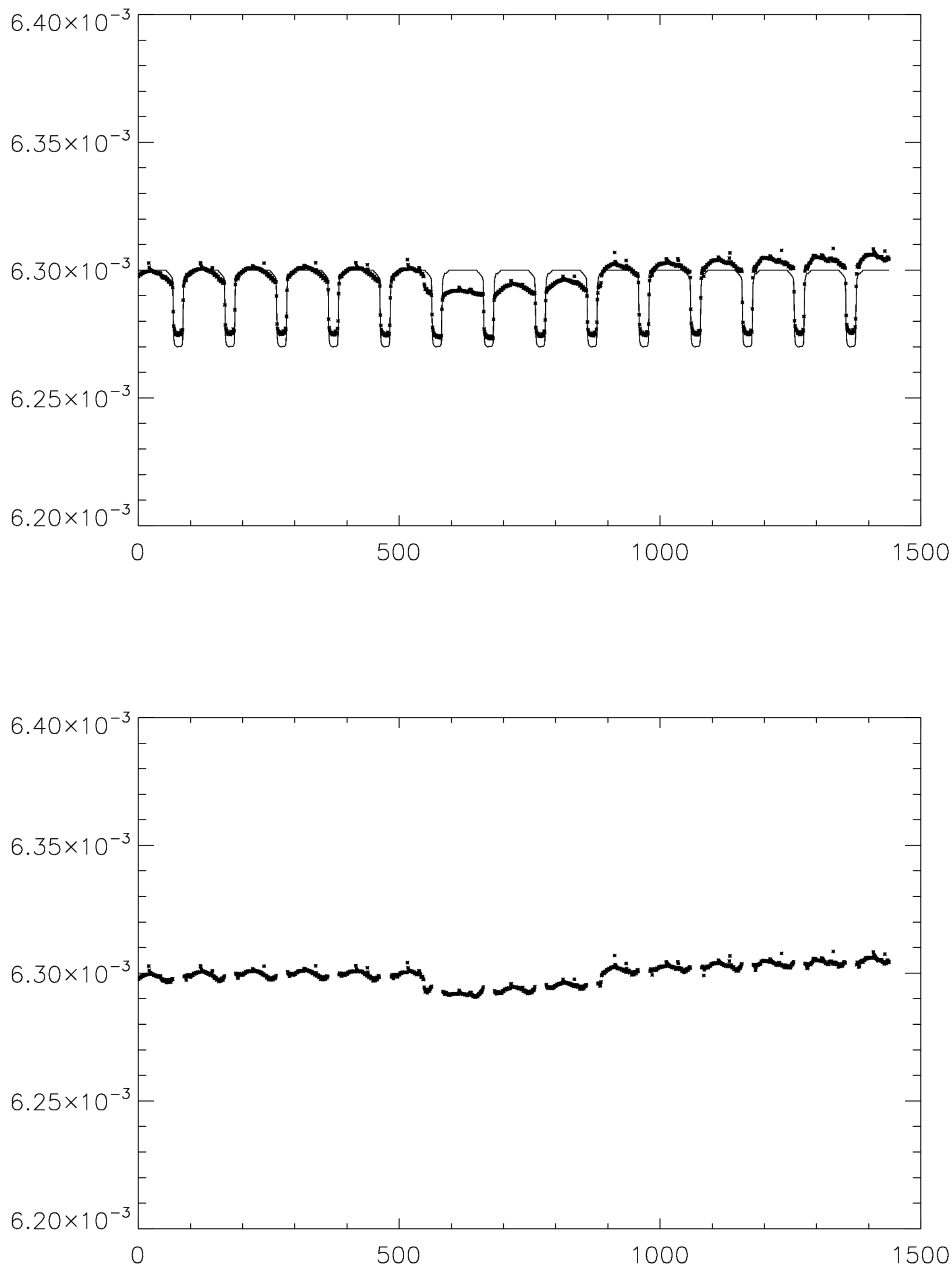


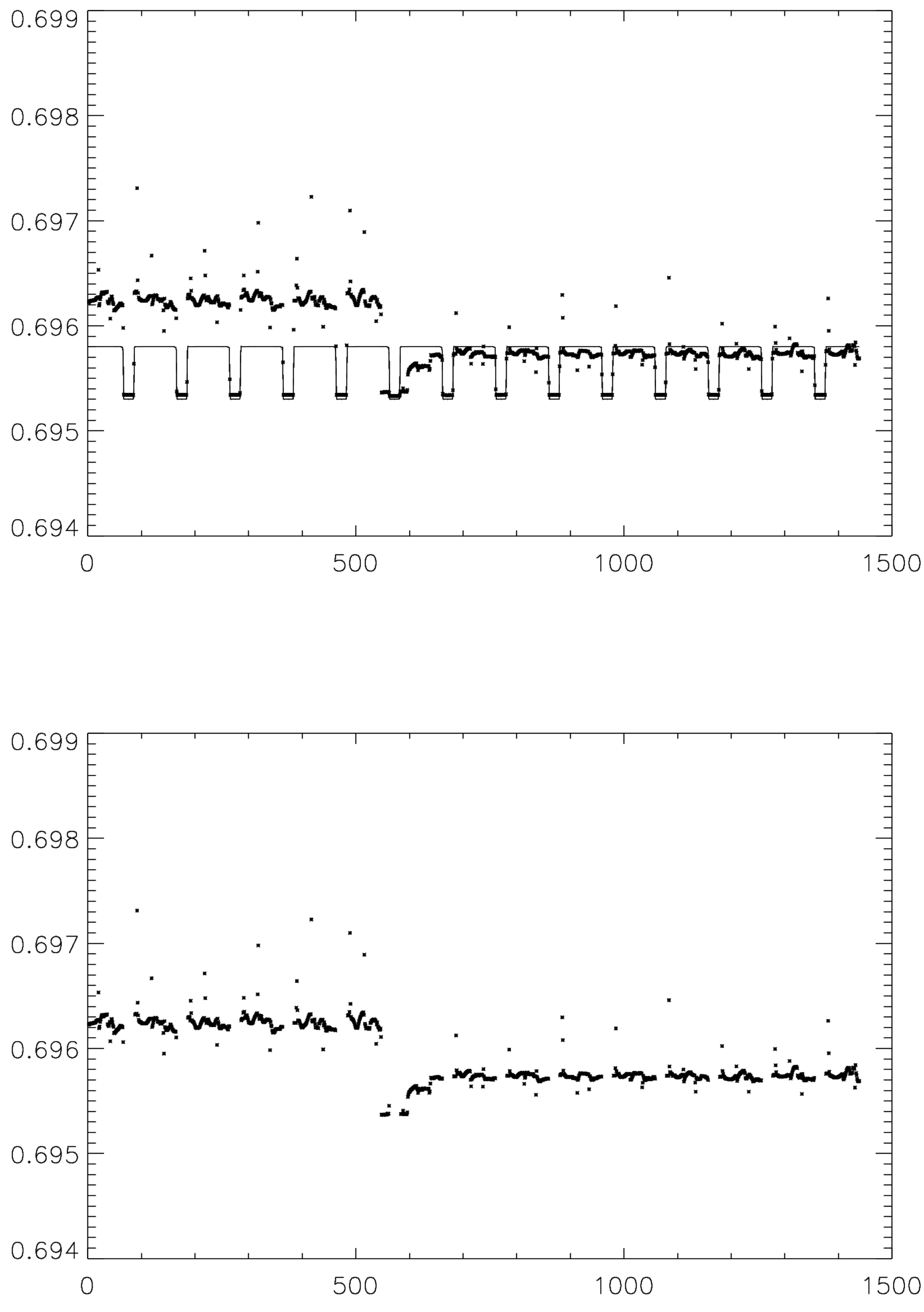
Figure 1: Scaled occultation profiles for Zirconium channel 2-4, days between 01 Oct 2013 to 28 Feb 2014, of which approx days 35 to 120 are significant. Above: ascending profiles, below: descending profiles.



<u>Figure 2:</u> Average scaled occultation profiles for the four channels of LYRA nominal unit 2 in season 2013/14. Straight lines = ascending, dotted lines = descending. Bumps in ascending profiles for ch2-1 and ch2-2 are artifacts due to low performance of these highly degraded channels.



<u>Figure 3 a:</u> Lyman-alpha channel 2-1 irradiance in W/m2 vs minutes of 05 Dec 2013. Above, before correction; asterisks are the observed values, the straight line is the simulated occultation profile. Below, after correction. Gaps are left for altitudes below 100km.



<u>Figure 3 b:</u> Herzberg channel 2-2 irradiance in W/m2 vs minutes of 05 Dec 2013. Above, before correction; asterisks are the observed values, the straight line is the simulated occultation profile. Below, after correction. Gaps are left for altitudes below 100km. (*Remark:* Due to the steepness of the ch2-2 occultation profiles, there is no real correction, simply the gap.)

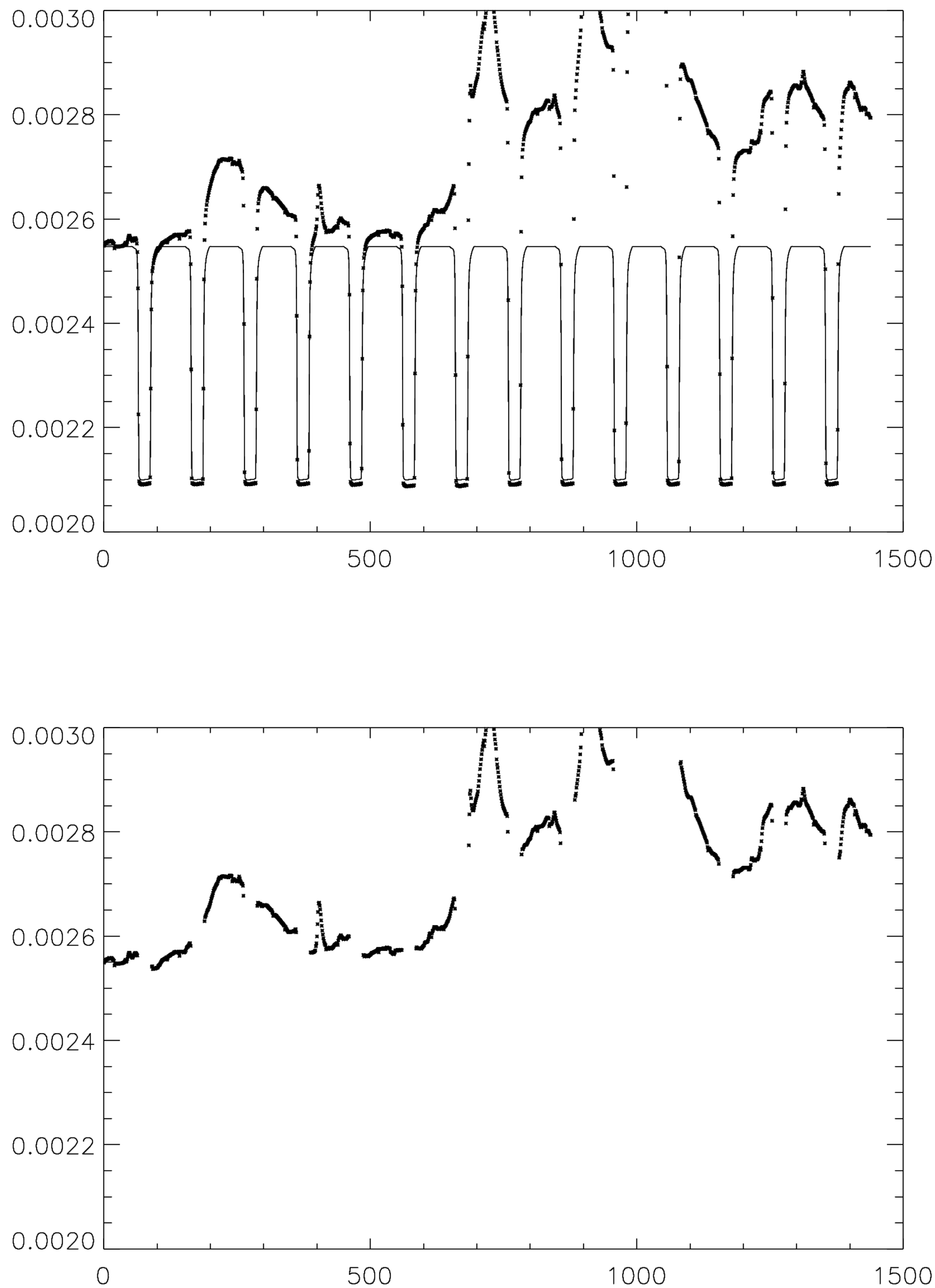


Figure 3 c: Aluminium channel 2-3 irradiance in W/m2 vs minutes of 05 Dec 2013. Above, before correction; asterisks are the observed values, the straight line is the simulated occultation profile. Below, after correction. Gaps are left for altitudes below 250km.

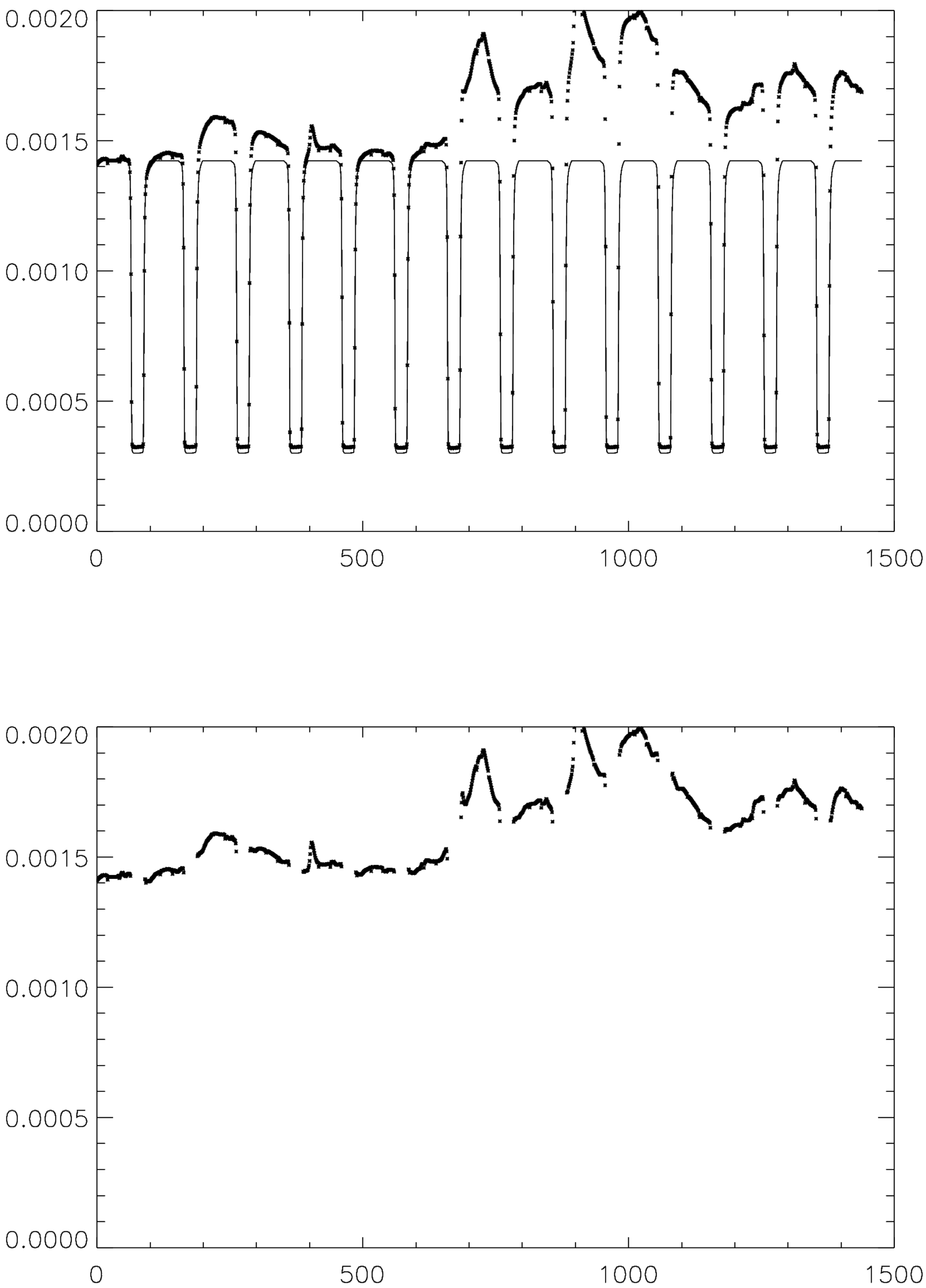


Figure 3 d: Zirconium channel 2-4 irradiance in W/m2 vs minutes of 05 Dec 2013. Above, before correction; asterisks are the observed values, the straight line is the simulated occultation profile. Below, after correction. Gaps are left for altitudes below 250km.