Comparing High-Latitude Thermospheric Winds From FPI and CHAMP Accelerometer Measurements

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Abstract It is generally assumed that horizontal wind velocities are independent of height above the F_1-region (> 300 km) due to the large viscosity of the upper thermosphere. This assumption is used to compare two completely different methods of thermospheric neutral wind observation, using two distinct locations in the high-latitude Northern Hemisphere. The measurements are from **ground-based Fabry-Perot Interferometers (FPI)**, and from **in-situ accelerometer measurements onboard the CHAMP satellite**, which was in a near polar orbit. The UCL KEOPS FPI is located in the vicinity of the **auroral ova**l at the ESRANGE site near **Kiruna, Sweden (67.8°N, 20.4°E)**. The UCL Longyearbyen FPI is a **polar cap site**. It is located at the Kjell Henriksen Observatory on **Svalbard (78.1°N, 16.0°E).** The comparison is done in a statistical sense, comparing a longer time series obtained during nighttime hours in the winter months (November to January); with overflights of the CHAMP satellite between 2001 and 2008 over the observational sites, within ±2° (±220 km horizontal range). The FPI is assumed to measure the line-of-sight winds at **~240 km height**. This is the peak emission height of the atomic oxygen 630.0 nm (red line) emission. The cross-track winds are derived from state-of-the-art precision accelerometer measurements at altitudes between **450 km (in 2001) to 330 km (in 2008);** i.e. 100-200 km above the FPI wind observations. In addition to testing the consistency of the different measurement approaches, the study aims to clarify the effects of viscosity on the height dependence of thermospheric winds.

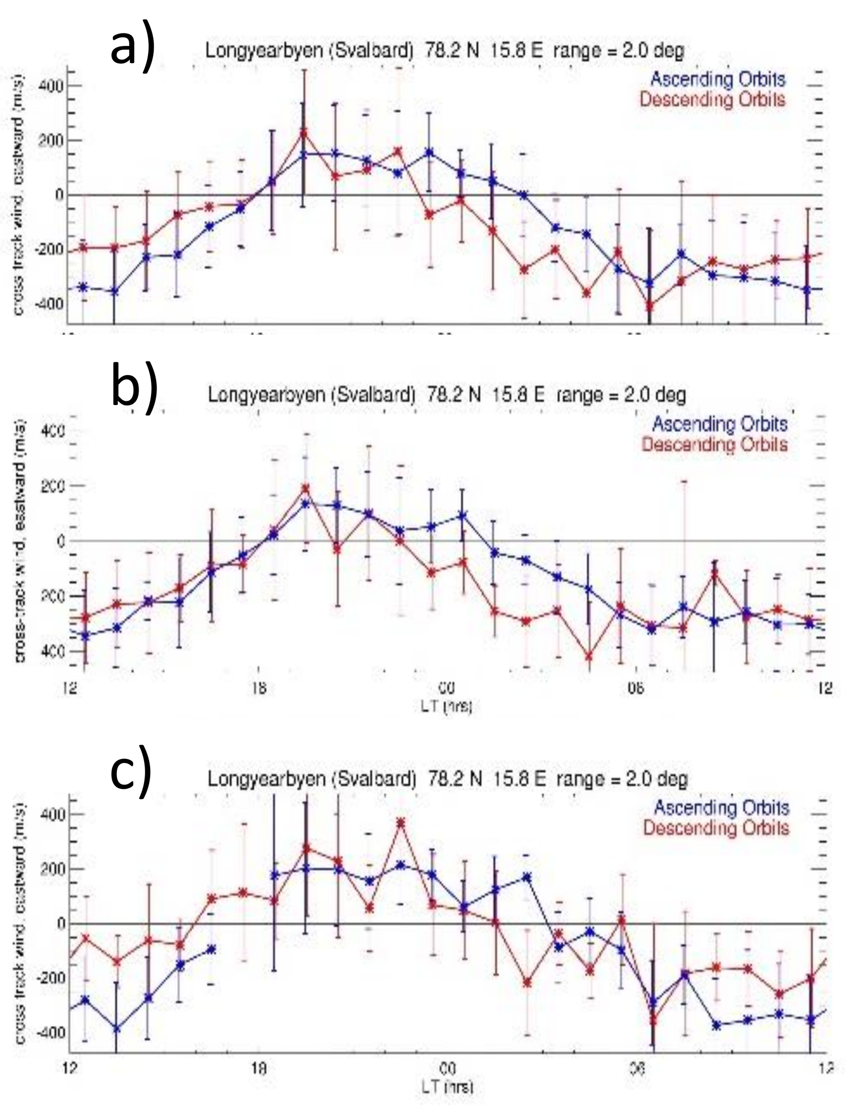


***Figure 1:** CHAMP observations over Longyearbyen during solar maximum 2001-2003*

a) All data – ascending (blue) and descending (red) averages
b) b) Summer (May-Aug) – ascending (blue) and descending (red) averages
c) Winter (end Oct-early Mar) – ascending (blue) and descending (red) averages.

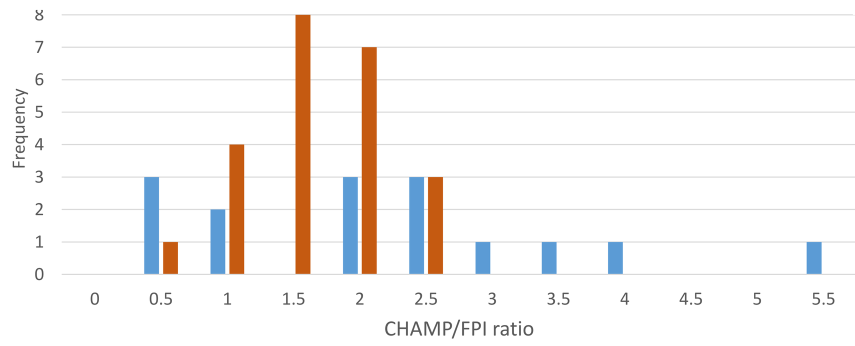


Figure 4** Frequency of occurrence of ratio values for CHAMP/FPI zonal wind magnitudes using one-hour averages measured for 2- < Kp < 4+ during Nov-Jan 2001-2004 at Svalbard (red) and Kiruna (blue) –* ***both large and variable.

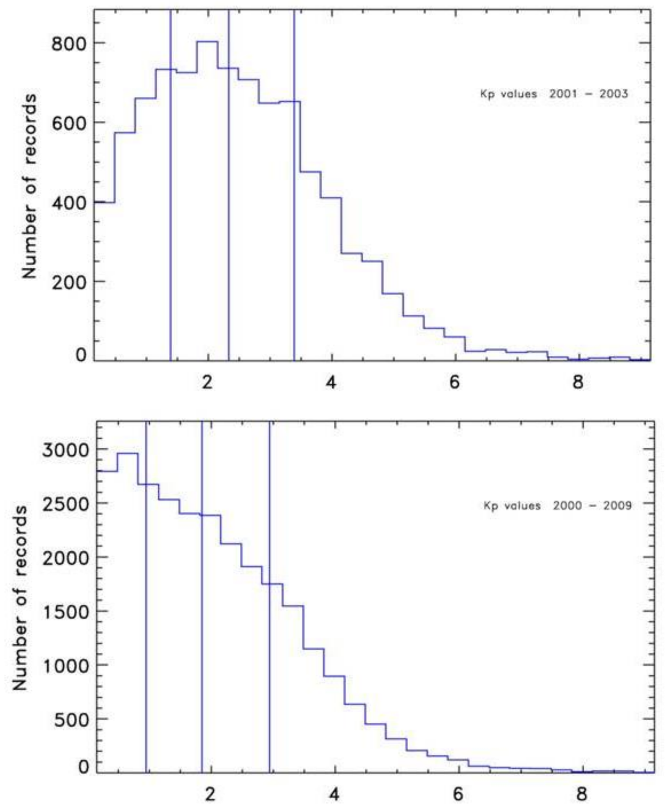


***Figure 5** Frequency distribution of Kp values. Top: 2001-2003 representing solar maximum. Bottom: 2000-2009 covering most of the period of the CHAMP lifetime.*

Svalbard: HWM87, HWM90 compared with CHAMP and FPI Zonal Winds from 1980 and 2001-2003

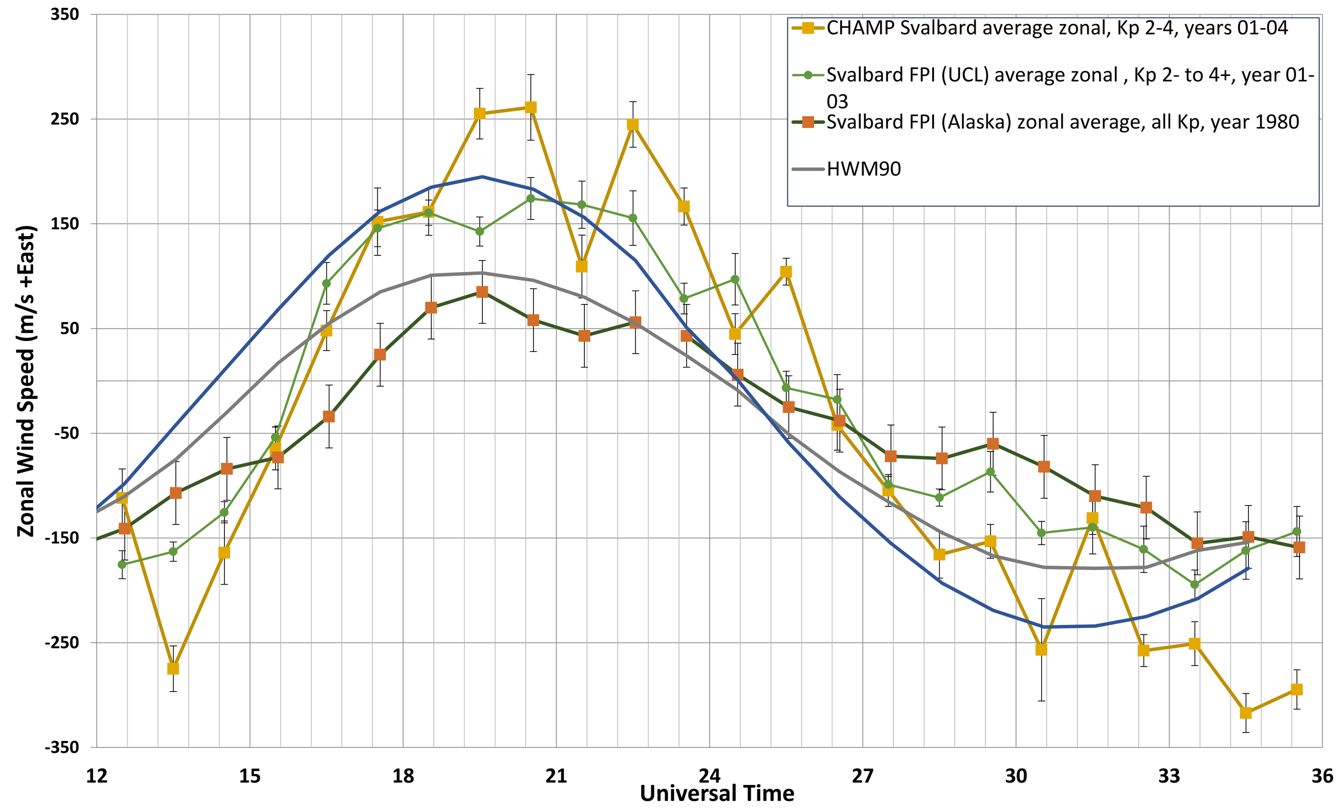
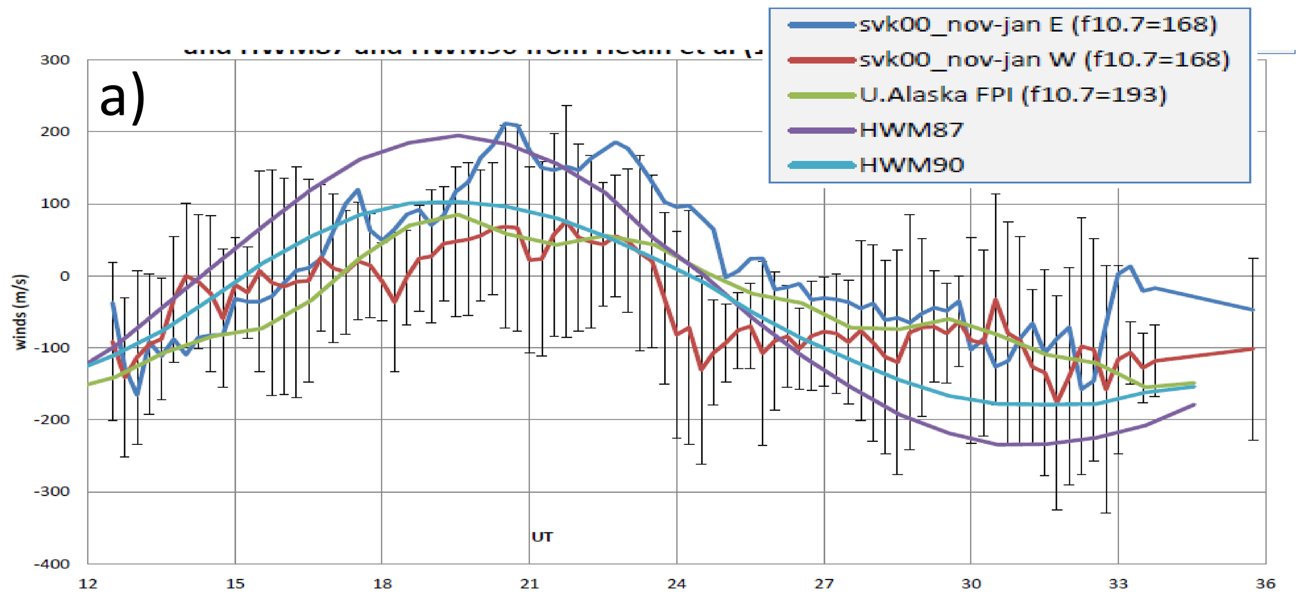


Figure 2 Longyearbyen (Svalbard) winters 2001-2003, 2<Kp<4: average zonal winds measured using CHAMP and FPI, including standard error of the mean. These are compared with Svalbard FPI winds observed by the Univ.ersity of Alaska in 1980 and the HWM87 and HWM90 model winds.



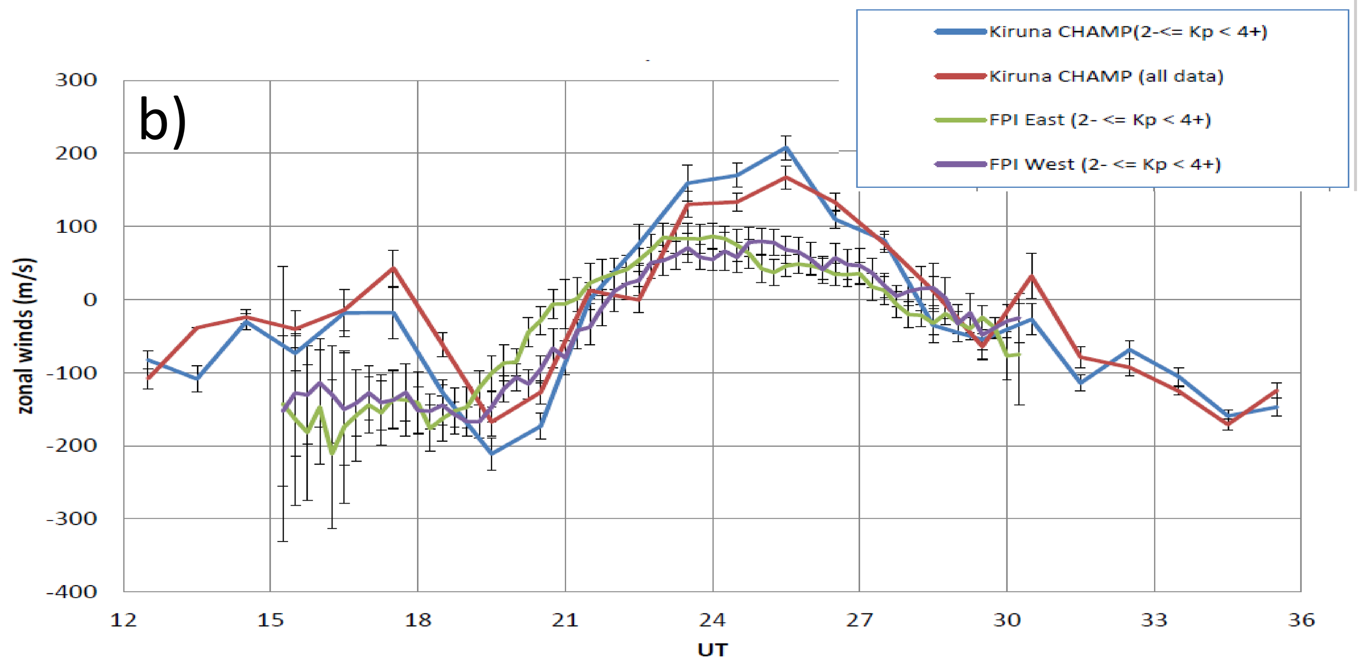


Figure 3 left

***a)** Longyearbyen (Svalbard) winters 1980 compared with 2000-2001, 2<Kp<4: zonal average winds , including standard error of the mean for the UCL FPI East look direction.*

***b)** Comparison of CHAMP and FPI measurements of Kiruna winters 2001-2004, 2-<Kp<4+: zonal average winds , including standard error of the mean.*

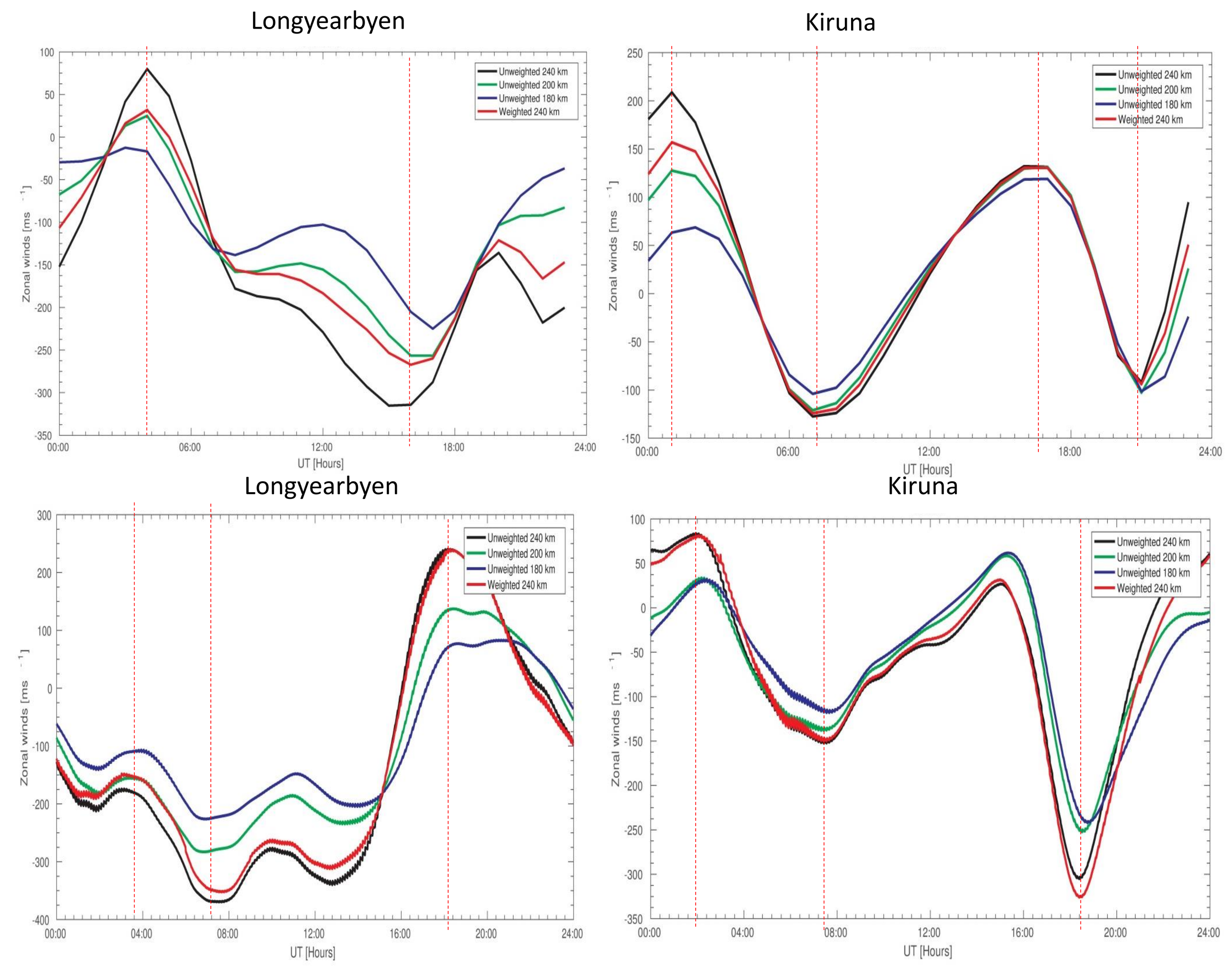
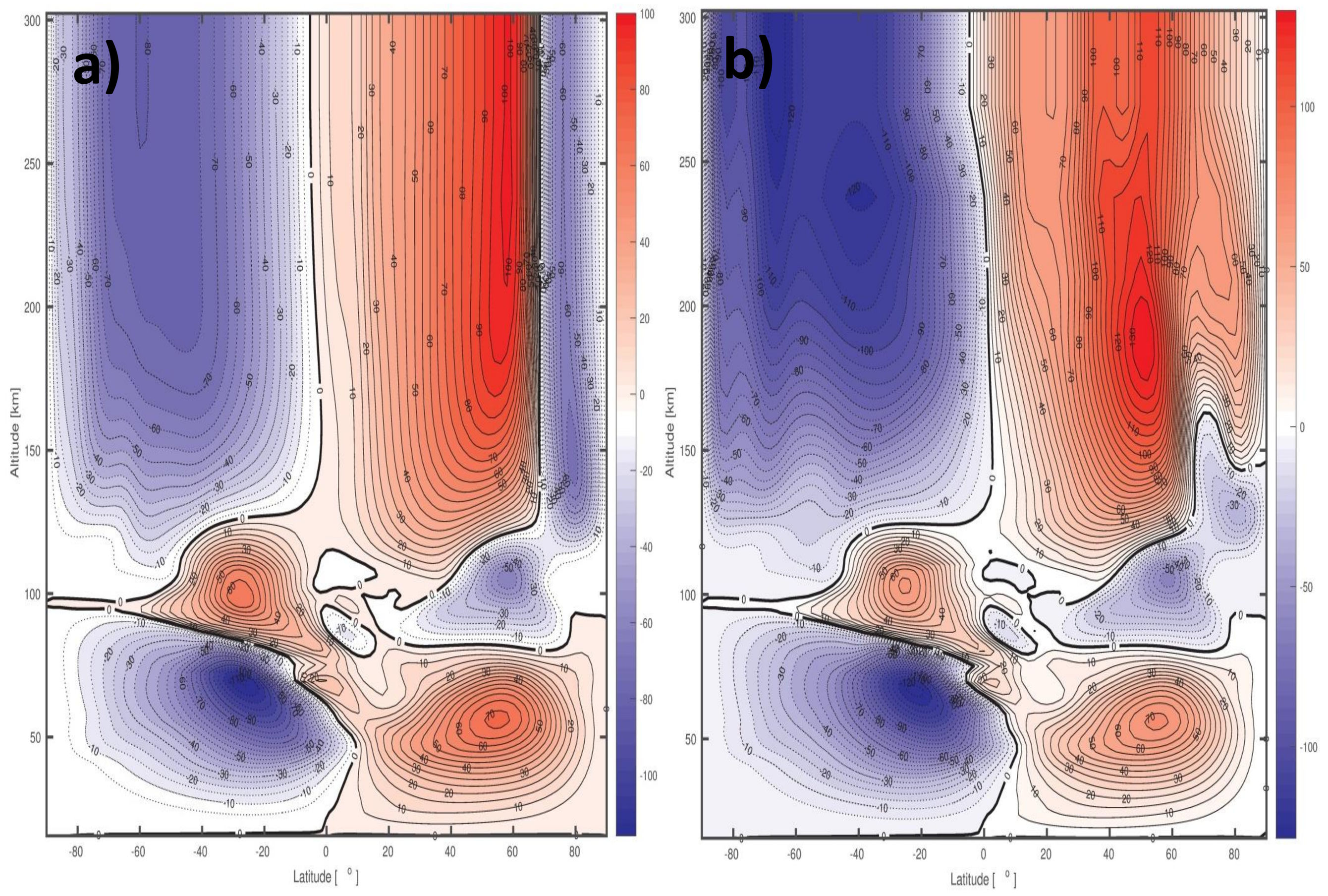


Figure 8 right: Local wind modelling: top row: *CMAT2 zonally averaged zonal winds for a quiet day on 1st December 2007 at Longyearbyen* ***(left)*** *and Kiruna* ***(right)*** *for the winds at 180, 200 and 240km for comparison with the height integrated winds weighted using an emission intensity profile from the Vlasov et al (2005) model.* ***Bottom row:*** *the same for active conditions on 20th March 2015.*

Conclusion

Satellites provide a crucial role in upper atmosphere research by filling in the extensive gaps between ground-based observations. Satellites provide 3-dimensional coverage at high spatial resolution, in addition to high temporal resolution. Meanwhile, ground-based instruments are sparse, land-based, and not always operational on a 24/7 basis owing to operational costs (e.g. incoherent scatter radars) or observing constraints (e.g. only night-time and clear sky observations for optical instruments). Having uncovered this discrepancy between ground-based FPI optical measurements and satellite drag measurements of winds, it is imperative to determine if it is a real altitude dependence, or if some re-scaling of winds, is necessary; either or both of FPI height-integrated Doppler shifts or satellite drag.

***Figure 6** CMAT2 zonally averaged zonal winds for 00UT at December solstice 2008 (solar minimum conditions) to demonstrate the effect of drastically reducing the molecular viscosity in order to raise the altitude where winds become independent of altitude. a)shows contours for a standard simulation, while b) represents a simulation where the molecular viscosity is 100 times smaller.*



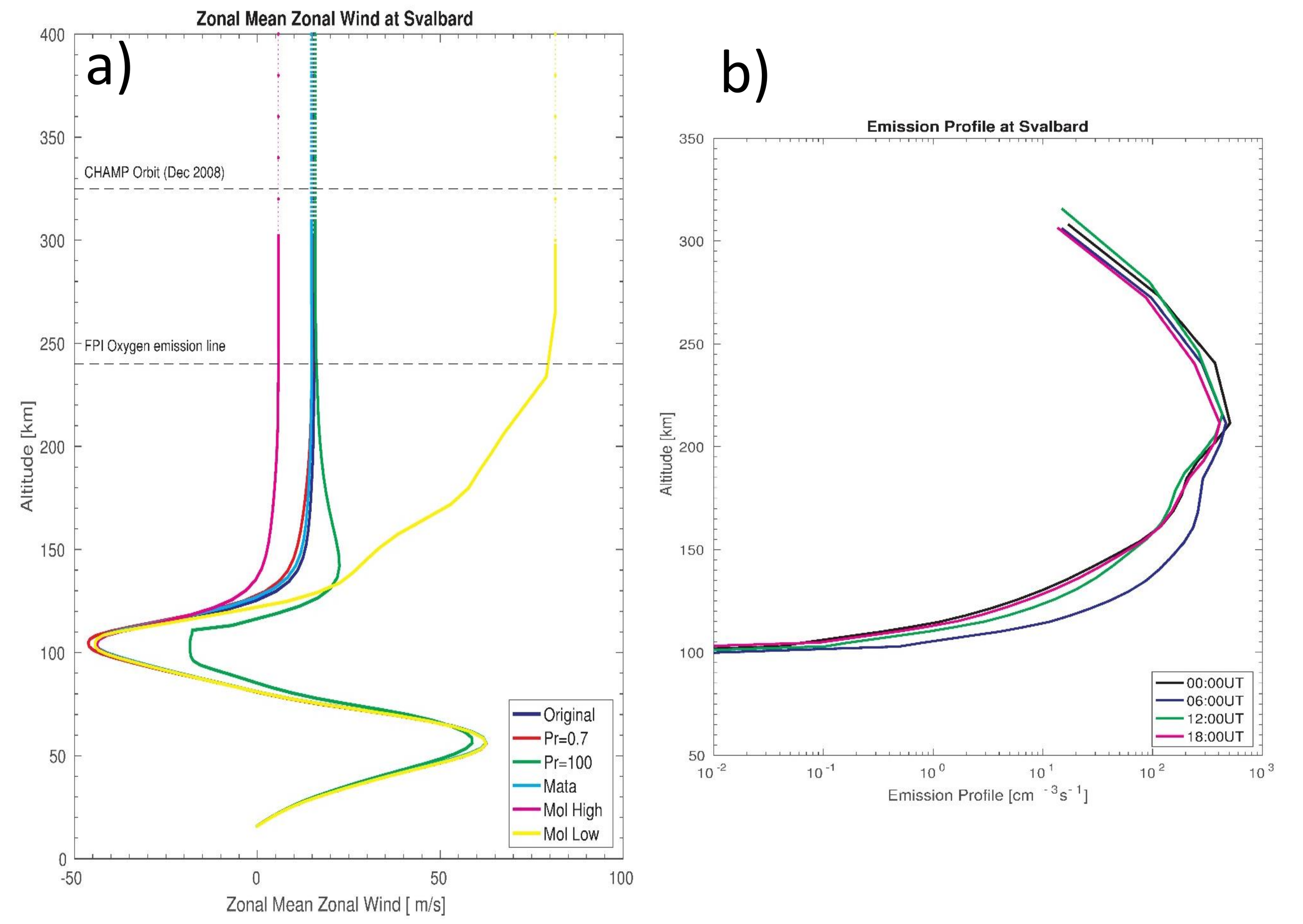


Figure 7 Modelling the height integrated winds

a) height profile of CMAT2 zonal winds at Svalbard.

b) height profile of the red line emission intensity profile from the Vlasov et al (2005) model.

Figure 9 right: Global wind modelling: *Pairs of longitude-latitude plots of CMAT2 zonal winds for a quiet day on 1st December 2007, comparing the zonal winds at 240km and the height integrated winds weighted using an emission profile from Vlasov et al (2005) model. The top pairs show 00UT and 06UT, and the bottom pairs show 12UT and 18UT.*