Characterization of wind and wind shear climatologies for ADM-Aeolus

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Atmospheric wind profiling from space is planned for 2011, in the frame of the Atmospheric Dynamic Mission Aeolus (ADM-Aeolus) of the European Space Agency (ESA). Wind profiles of the lowermost 30 km of the atmosphere are measured with a Doppler Wind Lidar (DWL). Under specific dynamically and optically heterogeneous atmospheric conditions, Aeolus wind measurements will be challenging, in particular because of its limited vertical sampling capability at only 24 levels. In this context, characterizing the climatology of wind and wind shear (dynamics) paves the way to define strategies to optimize the distribution of the vertical level bins for optimal use of ADM-Aeolus wind information for NWP and climate.

1 Introduction

Available worldwide high resolution radiosondes (Figure 1) and ECMWF model datasets are used to map the global climatology of the wind and wind shear profiles up to at least 30 km above the earth surface. The effect of the vertical scaling (resolutions) is investigated on single collocated radiosonde-model profiles (figure 2) and also statistically (figure 4). The results shown here are from the 2006 SPARC data collocated with the operational ECMWF model 12-hour forecast. This study is combined with another study (Stoffelen et al, 2009) that collocate the ECMWF winds with the space-borne CALIPSO lidar measurements to generate a realistic database of combined atmosphere optical and dynamical properties. The database is used to identify the most complex atmospheric states (dynamically and optically heterogeneous), needed for Aeolus-DWL simulations. In such conditions, errors may occur in the retrieved winds from the DWL, in particular due to the limitation to 24 of the available "adjustable" atmospheric vertical levels bins. To minimize errors in measurement and optimize wind retrieval for these cases, simulations are conducted to define the most-useful distribution of the vertical ranges-bins.

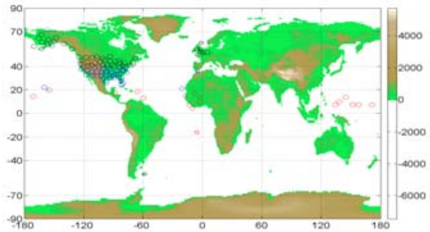

Figure 1: The geographical locations of analyzed high-resolution radiosonde datasets: SPARC (circles), BADC (hexagrams), AMMA (diamonds) and De Bilt (Square) as function of climate regions, successively for the tropics (red), Subtropics (blue), mid-latitudes (black) and Polar (magenta). Note the orography (brown). The right legend from zero meter and up indicates the altitude of the earth surface from sea-level; below sea level is masked white here.

2 Collocated radiosonde-model wind profiles

The left panel of Figure 2 shows the smooth ECMWF wind profile compared to the radiosonde profiles of different resolutions. The raw radiosonde wind profile shows much more detail as compared to model winds. In the right panel, the standard deviations generated by reducing the vertical resolution of the radiosonde wind profiles are shows .

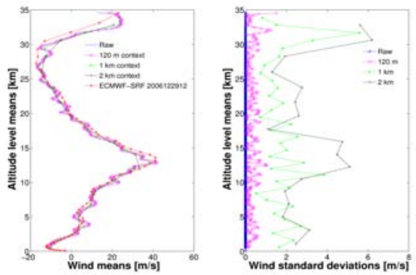

Figure 2: Effect of reducing the resolution of raw radiosonde zonal wind: wind profiles (left) of a radiosonde ascent for the raw 6s (30m) SPARC data (blue), and for successively degraded radiosonde resolutions with running averages over boxes of 120m (magenta), 1km (green) and 2km (black) with collocated ECMWF model wind profile (red); The right plot shows successively in the same colors for each resolution the standard deviation (SD) of the wind in each box.

3. Wind and wind shear statistics

Statistics for the horizontal wind and wind shear are established at each 1km atmospheric level bin and over different climate region. (figure 3), from high resolution radiosondes and ECMWF data. Figure 4 shows that wind distributions of both datasets are similar while for wind shear distributions are different.

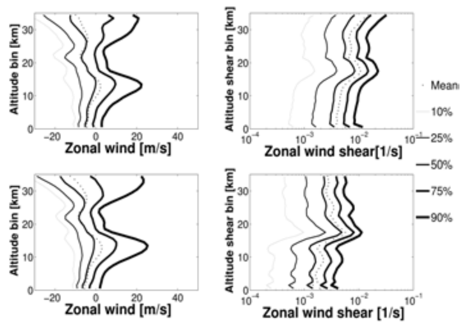

Figure 3: Zonal wind and wind-shear statistics for different climate regions based on high resolution 12s (~60 m) SPARC radiosondes (top) collocated with ECMWF SRF (bottom): mean (dots) and percentiles (successively from left to right: 10, 25, 50, 75, 90%); tropical case here for 2006 SPARC data of 9 radiosounding stations.

4. ECMWF effective resolution

To compare the difference in the statistics of the vertical variability of the horizontal wind between radiosonde observations and ECWMF model (figure 4), absolute wind shear ratios of successively degraded radiosonde resolutions (dz) and ECMWF are computed as given in Eq.1.

$$R_{dz}(z)=\frac{|Vsh_{dz}(z)|_{RS}}{|Vsh(z)|_{EC}} \qquad \text{Eq.1}$$

Where, Vsh is the mean or median of the absolute zonal or meridional wind shear.

Figure 4 shows also that the effective ECMWF model vertical resolution is ~1.7 km which much coarser than the model grid resolution

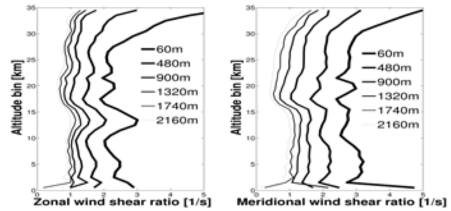

Figure 4: Zonal (left) and meridional (right) wind shear ratios of a series of successively degraded radiosonde resolutions and the ECMWF model absolute wind shear. This example is from the subtropics, similar result have been obtained for the other climate regions (not shown)

5. Conclusion

It is found that the climatology of the horizontal wind from radiosonde observations and the ECMWF model is generally similar while for the wind shear is underestimated in the model with a factor of 2.5 in the zonal wind and 3 in the meridional. It is found that the ECMWF effective vertical resolution is typically 1.7 km. The evaluation of wind and shear radiosonde-model differences shows that wind may lack a variances exceeding 5 m/s and 15 ms⁻¹/km, near the jets in particular. rom these results and based on the ECMWF model, a method is developed to built a dynamically and optically realistic database needed for the Aeolus DWL simulations.

References: Ad. Stoffelen et al, 2009, Assessment of Optical and Dynamical Atmospheric Heterogeneity, available through KNMI, AE-TN-KNMI-VAMP-002_v7_KNMI_150609, version: 0.8, 15 June 2009

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