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Assessment of the impact of zonal component of Radiosonde winds: A prelude to the assimilation of Aeolus winds

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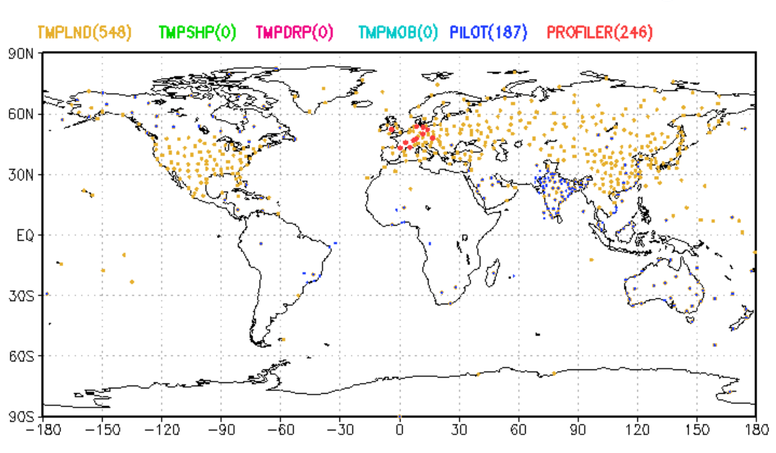
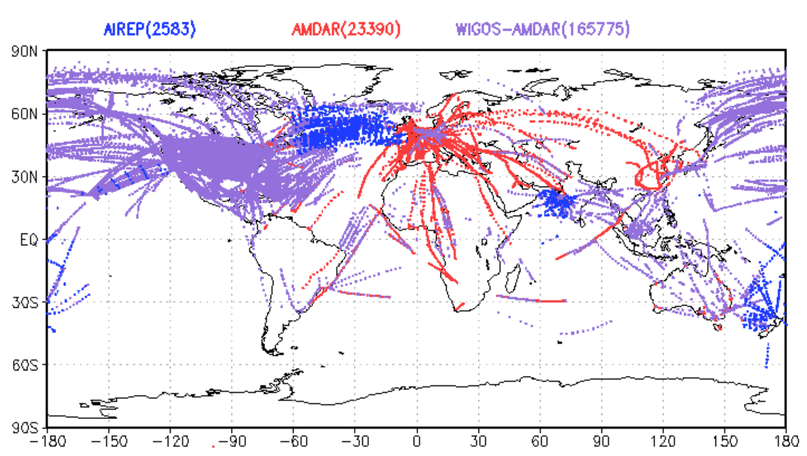
Background

Wind observations are very important for the better atmospheric analysis particularly over the Tropics where wind fields govern the dynamics, rather than the mass fields. There is a lack of homogeneous global coverage of direct wind profile measurements in the current Global Observing System. Uniformly distributed direct wind observations are important for smaller scales and deeper atmospheric structures.

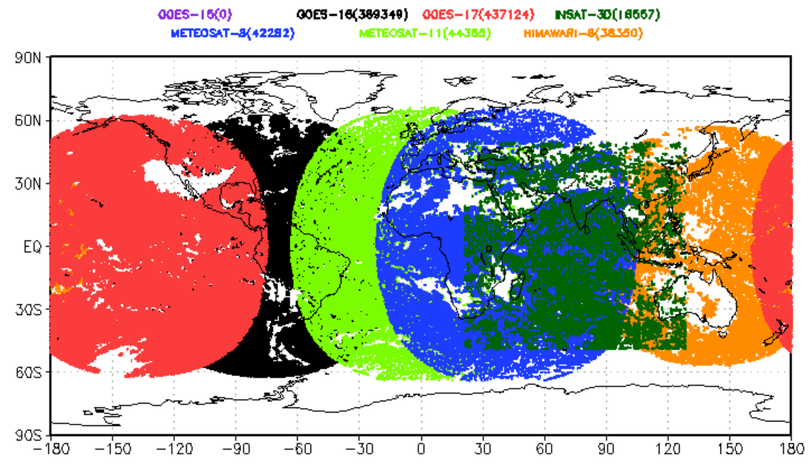
Global Radiosonde and PILOT Balloon Coverage



Global Aircraft coverage

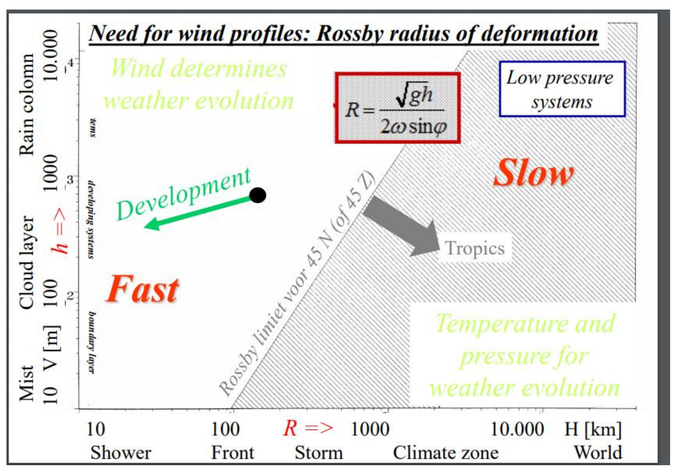


Global geostationary satellite coverage

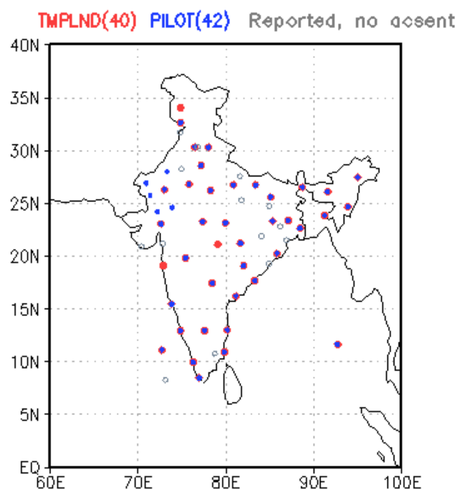


A few Radiosonde and Aircraft observations over the Southern Hemisphere. Radiosonde profiles are limited only over the Northern Hemisphere land regions. Though satellites provides global winds, they are limited to some particular levels of the atmosphere, not like Radiosonde profiles.

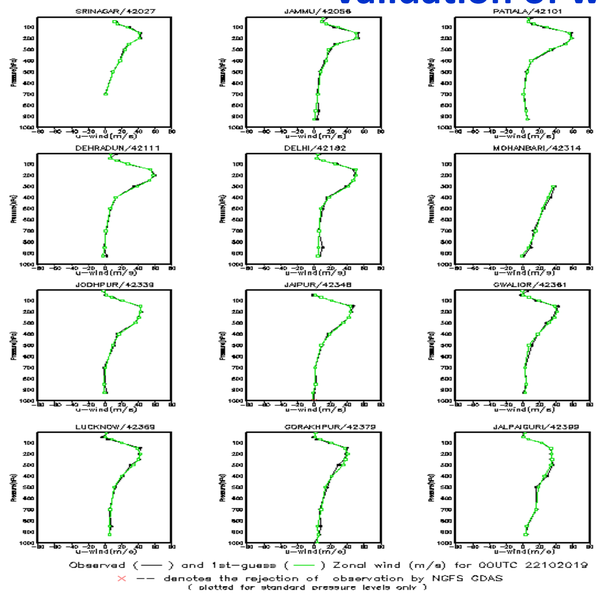
Need for Wind Profilers

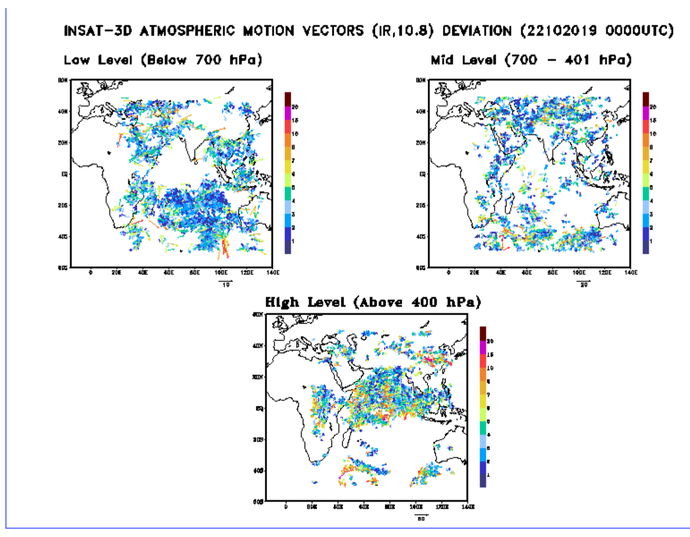


Radiosondes Over India



Validation of winds Over India



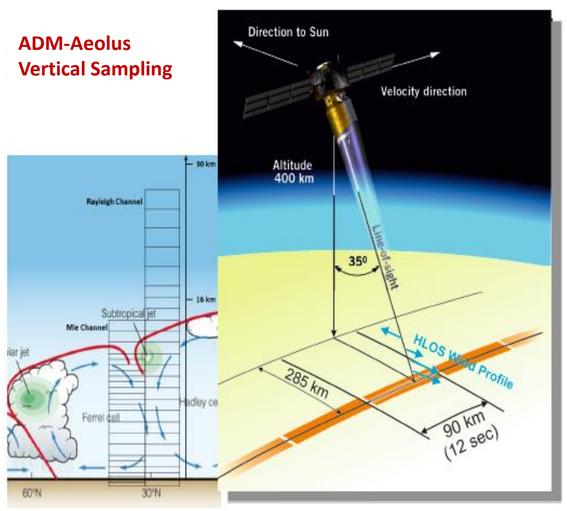


Space-based wind Lidars provide spatially, vertically and temporally continuous wind observations which are pivotal for NWP. ADM-Aeolus wind Lidar delivers homogeneous wind suitable for NWP assimilation. The main product from Aeolus is the Horizontally projected Line Of Sight (HLOS) wind component, a single component of wind information, approximately zonal in nature.

ADM-Aeolus Measurement principle

Measurement baseline

ADM-Aeolus Vertical Sampling



Previous Investigations : Single-component vs full vector

Loren et al., (1991) reported that assimilating a single wind component gives more than half the impact of assimilating the complete wind vector, and there was no detrimental effect from assimilating a single vector component.

Horyani et al., (2015 A and B) discussed the importance of assimilating wind as either a single-component or a vector in the ECMWF assimilation and forecast system. Single-component and vector winds from conventional observations were assessed in their study.

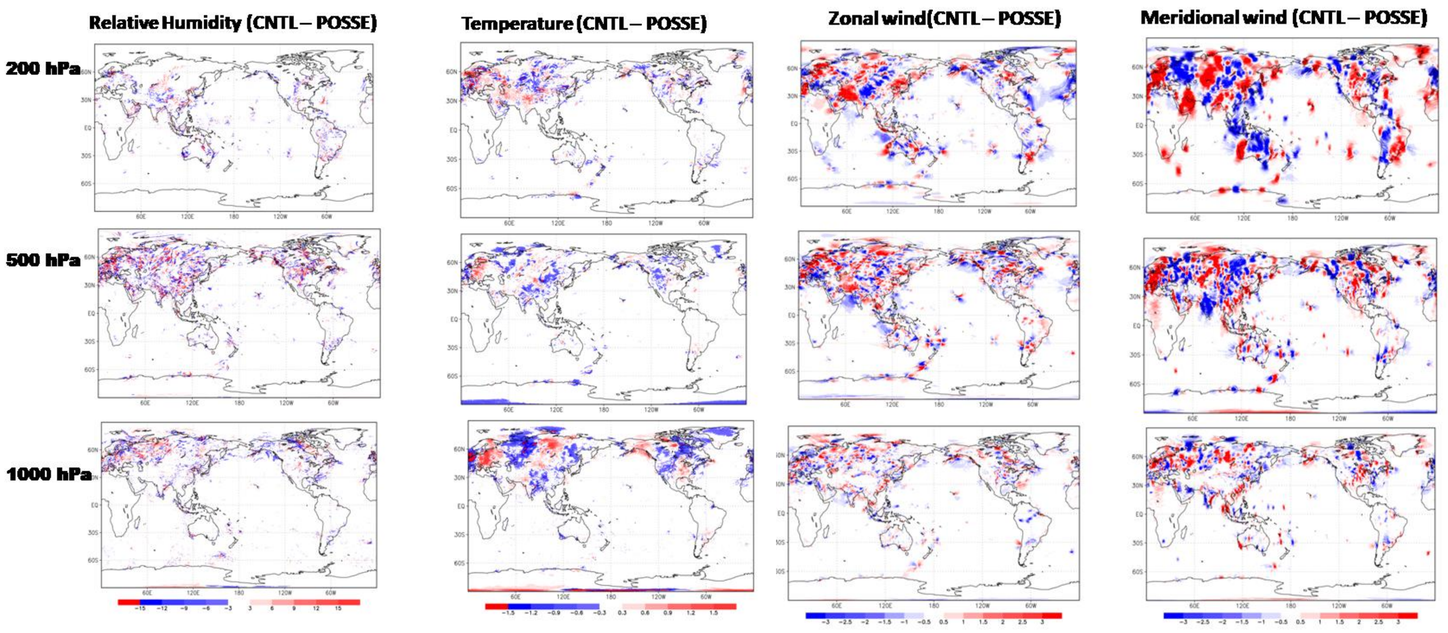
Their evaluation of the impact of conventional wind observations on the analysis and forecast with respect to mass observations has shown that the assimilation of wind observations leads to a statistically significant, large improvement on wind and temperature forecast fields in the upper troposphere, lower stratosphere and in the Tropics. It was found that in the Tropics the large wind impact dominates at all levels, while in the mid-latitudes mass observations are more valuable particularly in the lower part of the atmosphere (i.e. below 500 hPa); this finding agrees with geostrophic adjustment theory.

Their investigation also highlighted that the impact of zonal wind observations is larger than the meridional wind. Root mean squared errors of temperature and wind forecasts when the single wind component (zonal) is assimilated show around 35% degradation up to day 2 forecasts and around 20% after day 2 as compared to assimilating full vector wind. Therefore the single (zonal) wind components can provide a large fraction of the vector wind impact particularly for the medium-range forecast, which is promising for Aeolus.

Experiment Set up

Before assimilating ADM-Aeolus winds, a pseudo Observation System Simulation Experiment (POSSE) was conducted with only the zonal component of radio sonde (RS) winds to assess the impact of single component of wind information in the NCMRWF assimilation and forecast system compared to the full vector wind. Two experiments were designed, in the first full RS winds are assimilated (CNTL) and in the second only the zonal component of RS winds (POSSE) are assimilated. Both the experiments were run continuous 15 days from 1 to 15 May 2018.

Vector winds are decomposed into zonal and meridional components, assimilated only the zonal component and assigned the wind direction purely from either east or west.



Single vector component assimilation reproduces approximately 75-80 % characteristics of full vector assimilation. Differences in meteorological fields like Temperature, Relative Humidity, Wind components, etc., are noticed at higher levels particularly over the tropical orographic regions.