Using dual-polarized radar data in LAPS system

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1 Introduction

The NOAA (US National Oceanic and Atmospheric Administration)'s Local Analysis and Prediction System (LAPS, Albers et al., 1996) is specifically designed to create multi-instrument analysis fields for the assimilation into limited area atmospheric models (LAMs) and/or standalone as an advanced nowcasting system. Laps can ingest all available data sources: surface (SYNOP, METAR and data from automatic weather stations), soundings, satellite and radar data. The aim is to create analyzed fields with the focus on the mesoscale weather systems and build products for specific forecast applications. To accomplish this goal the radar data play a very important role. Beside standard analyses (temperature, wind, humidity, pressure) LAPS performs cloud analysis, as well, all with an adjustable spatial and temporal resolution. The method is based on two stages approach (McGinley et al., 2000) which is schematically presented in Figure 1. First, the data from every meteorological system are mapped onto the LAPS grid separately and then they are used in the LAPS analyses using the Barnes multiple iteration successive correction method or in the process of minimizing the cost function.

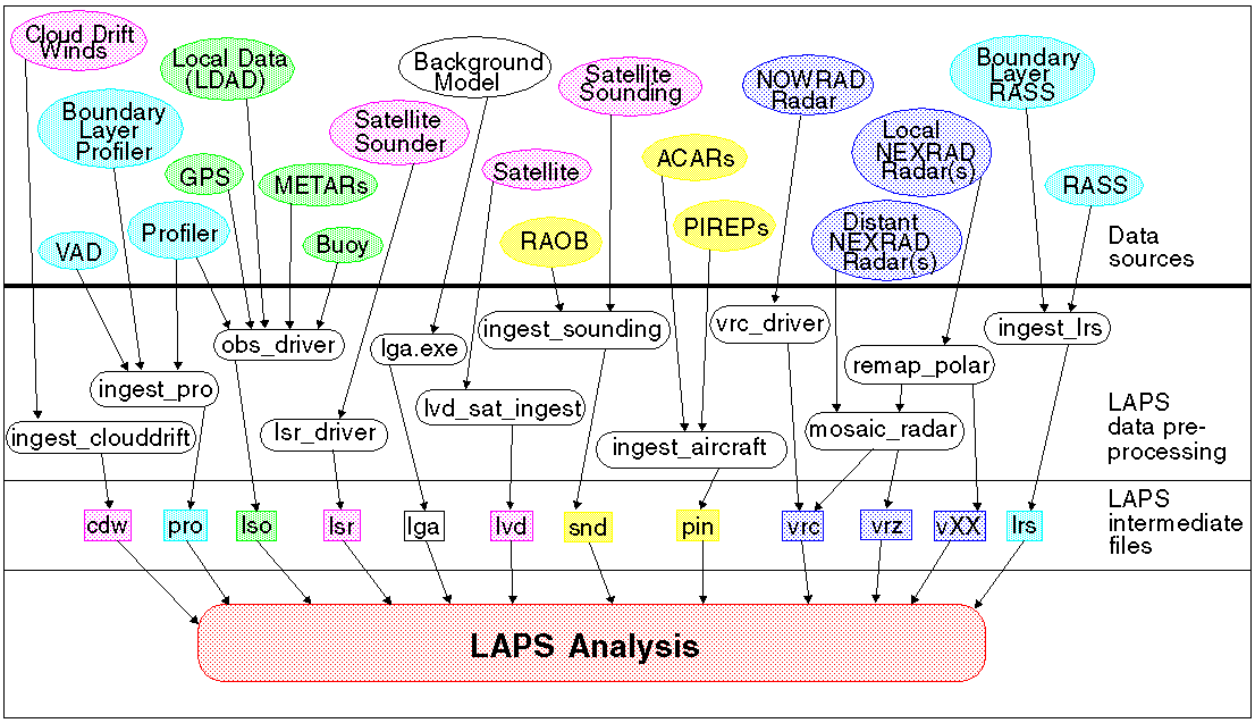

Figure 1: The LAPS ingestion scheme (laps.noaa.gov)

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2 Using radar data in the LAPS analyses

Originally, radar reflectivity and Doppler velocity data are used in the LAPS wind and cloud analysis. The wind analysis is generated using surface observations, profiler data, cloud drift winds and aircraft reports. Background model grids are

used as a first guess and to do quality control on new observations. The wind analysis is done in three steps. The first step analyses the non-radar data with the background wind field using a multiple iteration successive correction technique. For the second step, the first step results are used as the background. The data used includes non-radar data and any grid-points with multiple-Doppler radial velocities are also mixed in. Radial velocities are taken from the Doppler radars after dealiasing and other quality control steps are done. If two or more radars illuminate a given grid-point, a full wind-vector is constructed from a combination of the radial velocities and the preliminary non-radar analysis. This is done via a "successive insertion" process, beginning with the background (non-radar analysis), then followed with the radial velocity from each radar in sequence. For the final step the background field comes from the result of the second step. All point data is now used, including grid-points illuminated by only a single radar. The tangential component for each radar observation is estimated by using the background from the previous step (i.e. non-radar data and/or multi-radar data). Described procedure is shown schematically in Figure 2.

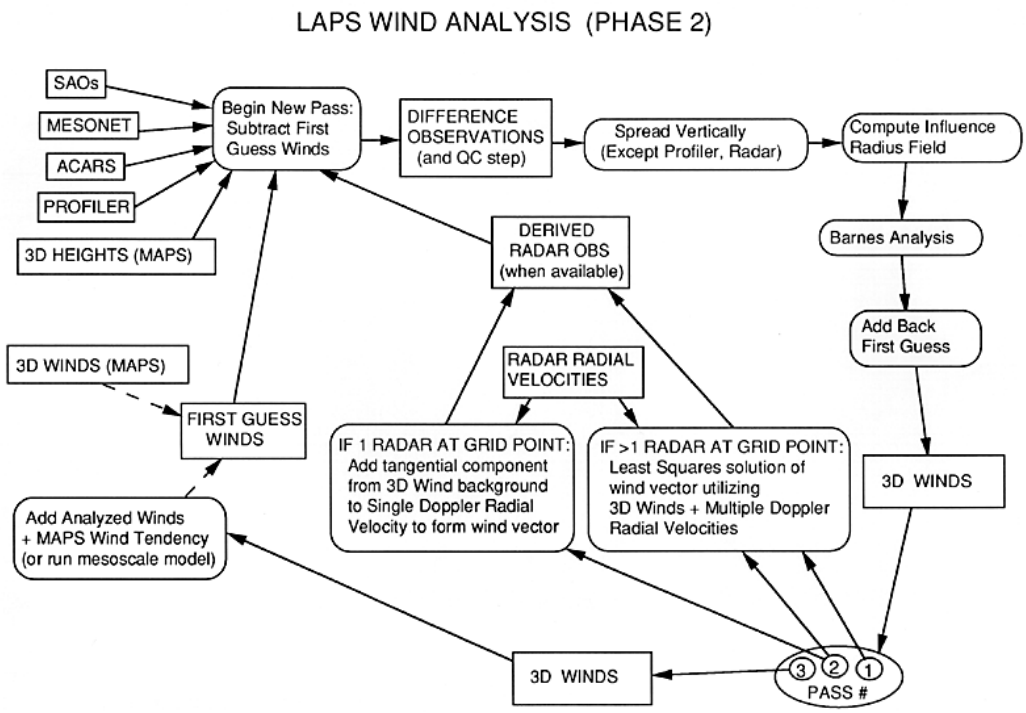

Figure 2: The LAPS wind analysis (laps.noaa.gov)

The cloud analysis combines the 3D temperature analysis, a 3D LAPS radar reflectivity analysis derived from full volumetric radar data, and a cloud top analysis derived from satellite data with cloud layer data from METAR's and SYNOP's reports. The vertical cloud soundings from METAR's and pilot reports are analysed horizontally to generate a preliminary three-dimensional analysis. This step provides information on the vertical location and approximate horizontal distribution of cloud layers. The satellite cloud-top temperature field is converted to a cloud-top height field using the three-dimensional temperature analysis. The cloud-top height field is then inserted into the preliminary cloud analysis to better define the cloud-top heights as well as to increase the horizontal spatial information content of the cloud analysis. Finally, the three-dimensional radar reflectivity field is inserted to provide additional detail in the analysis. The cloud analysis is shown schematically in Figure 3.

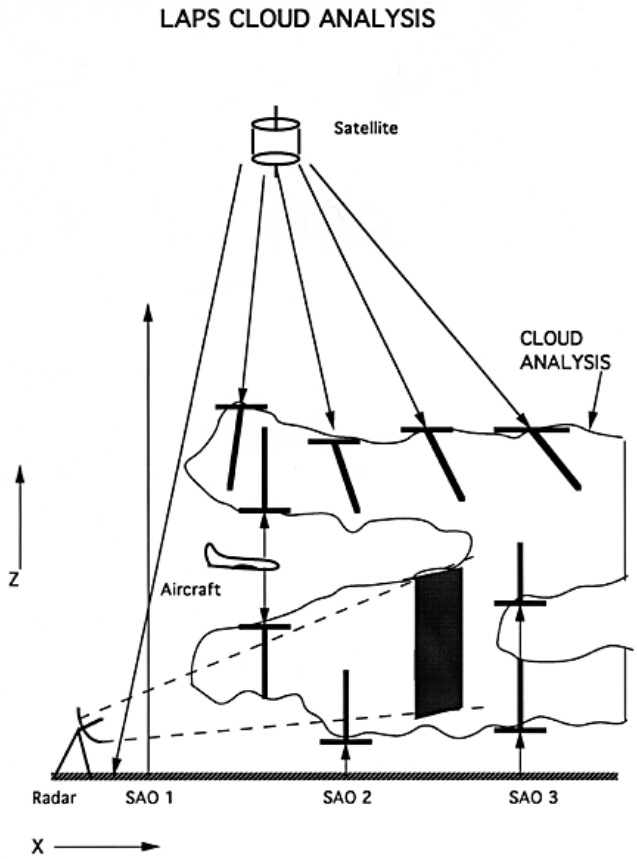

Figure 3: The LAPS cloud analysis (laps.noaa.gov)

2.1. Using dual-polarized radar data in LAPS

Originally, precipitation accumulation analysis was performed with radar reflectivity data which are blended together with surface precipitation measurements in the Barnes multiple iteration successive correction method. The rain rate is calculated using Z-R relationship for the Marshall Palmer drop size distribution in the form: $\mathbf{Z = 200R^{1.6}}$ (Marshall and Palmer, 1948). It is known that this relation has optimum for stratiform precipitation. In the cases of convective precipitation there are many disadvantages using this estimator. Beside different drop size distribution in convective clouds there are a very large attenuation of radar signal (loss). Also, total rain amount is biased by the presence of hail. Speeciffic differential phase parameter (KDP) is proportional to $D^{4.24}$ where is D rain drop diameter, compared to $Z \sim D^6$, and it is almost linearly related to rain rate: $\mathbf{R=40.6K_{DP}^{0.866}}$ (Sachidananda and Zrnic, 1987). The LAPS code is upgraded with remap and mosaic process of specific differential phase parameter with the aim to allow the calculation of precipitation amount based on $R=40.6K_{DP}^{0.866}$ relation in the cases of heavy rainfall. Precipitation estimation performed in LAPS will forced HBV hydrological model.

Also, hydrometeor classification is done based on Park et al., 2008 paper and it is incorporated in LAPS together with the LAPS temparature analysis to create 2D and 3D hydrometeor fields.

References

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