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# ON THE RELATIVE IMPORTANCE OF OPERATIONAL AIRCRAFT WINDS AND SATELLITE-DERIVED WINDS IN THE DEPICTION OF ATMOSPHERIC FLOW IN THE NORTH PACIFIC

Patricia M. Pauley* and Edward H. Barker
Naval Research Laboratory, Monterey, California

## 1. INTRODUCTION

Graham et al. (2000) performed an assessment of which data types are most critical for accurate 60-h forecasts of sea-level pressure in mid-latitude weather systems. Their results showed that for their ten oceanic cases (seven in the North Atlantic and three in the North Pacific), aircraft winds were the data type that had the greatest individual benefit, followed by (in order) rawinsonde winds (both land and ship-based), conventional surface data, satellite feature-track winds, and satellite temperatures. Rawinsonde temperatures and humidities, aircraft temperatures, and scatterometer winds were at best of secondary importance in these forecasts. The results from this study and others emphasize the importance of operational aircraft data in data assimilation. The present study was undertaken to assist in optimizing the use of aircraft and satellite winds in the Navy Atmospheric Variational Data Assimilation System (NAVDAS), the Navy's next-generation data assimilation system, which is being readied for operational implementation.

## 2. DATA UTILIZATION IN NAVDAS

NAVDAS is a three-dimensional variational data assimilation system cast in observation space. Details of the design and construction of NAVDAS are given in Daley and Barker (2000, 2001). As pointed out by Barker et al. (2001), observation preparation tasks such as quality control and thinning are incorporated in NAVDAS to ensure that the system can be run remotely at regional sites. Since a description of the system is given elsewhere in this volume (Barker et al. 2001), the discussion in this section will focus on aspects of the observation processing in NAVDAS.

### 2.1 Aircraft Observations

Aircraft data used in NAVDAS include MDCRS (Meteorological Data Communications and Relay System) data (sometimes referred to as ACARS data), AMDAR-format (Aircraft Meteorological Data Relay) data, and AIREP-format (Aircraft Report) data. MDCRS data are received at Fleet Numerical Meteorology and Oceanography Center (FNMOC) in BUFR format; these data are fully automated winds and temperatures from participating U.S. air carriers. AMDAR-format data are received in ASCII and are also fully automated data, but from non-U.S. air carriers. Airlines in Australia, New Zealand, Europe, and southern Africa provide AMDAR-format data. Conventional voice AIREPs are required for air traffic control purposes as aircraft pass specified waypoints on transoceanic flights. AIREP data received at FNMOC are pre-processed by Detachment 7, Tinker Air Force Base. Tinker translates named waypoints into latitude and longitude coordinates for voice AIREPs and re-encodes AMDAR-format and some ACARS-relayed automated reports into AIREP format. Most of the re-encoded reports received from Tinker are rejected as duplicates of AMDAR and MDCRS reports.

After these data are decoded and preliminary checks performed, the NRL Aircraft Data Quality Control (NAQC) system is run. A test of the NAQC system for a two-week period in February 2001 revealed duplicate percentages and reject percentages (in parentheses) of 1.6% (3.5%) of MDCRS reports, 1.2% (1.2%) of AMDAR-format reports, 81.5% (1.8%) of re-encoded AIREPs, and 15.9% (9.5%) of voice AIREPs. NAQC is a rule-based system that consists of a series of seven scans operating on all available aircraft data. The scans perform checks for (1) duplicates, (2) obviously invalid reports, (3) constant values, (4) gross errors, (5) inconsistencies in similar reports, (6) track errors, and (7) suspect values. The last scan also rejects reports from any flights/aircraft in which more than 35% of reports were rejected by previous checks. Rejected reports are removed from consideration at the end of each scan. Details of the NAQC system are given in Pauley (2001).

After the aircraft data have passed the NAQC checks, they are subjected to a buddy-check algorithm in NAVDAS that operates on all data types, not just aircraft data. This algorithm rejects

* Corresponding author address: Patricia M. Pauley, Naval Research Laboratory, 7 Grace Hopper Avenue, Monterey, CA 93943; e-mail: pauley@nrlmry.navy.mil.

observations that are collocated, that deviate too far from the background, or that are outliers.

Finally, the aircraft data are thinned. Ascent soundings from the automated data types are the most valuable to NAVDAS; they are treated as a profile and processed in a manner similar to rawinsonde data. The "best" ascent at a particular airport is chosen based on criteria such as minimum deviation from the vertical and proximity to the analysis time. An average position (latitude and longitude) is then assigned to the whole ascent. Remaining ascents at that location are not used. Descent soundings are used only if ascent soundings are not available. Level-flight reports including AIREPs are treated as single-level observations. Some thinning is also applied to these data, but future work is planned to devise an "intelligent" thinning algorithm that will perform both along-track thinning in some of the denser MDCRS tracks and aircraft-to-aircraft thinning to preserve the best possible data to assimilate. Larger observation errors are assigned to AIREPs, since these voice-relayed reports are susceptible to a host of errors, such as misunderstood words and encoding errors, that degrade the high quality of the observations themselves (Sparkman et al. 1981).

### 2.2 Satellite Feature-Track Winds

The processing for satellite feature-track winds is quite different from that for aircraft data. Essentially the same methodology is used to generate these winds at the various centers that process feature-track winds. Since these winds have much less variability on smaller scales than aircraft winds, the decision was made to "superob" them. This section describes the techniques used in computing superobs, as well as performing quality control.

In order to be able to assess any bias that is present in the feature-track winds, superobs are computed only for like data. Separate superobs are computed for winds processed by NESDIS (National Environmental Satellite, Data, and Information Service), CIMSS (Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin), and EUMETSAT (European Organization for the Exploitation of Meteorological Satellites). Furthermore, separate superobs are computed for each satellite (GOES-8, GOES-10, Meteosat-5, Meteosat-7, GMS) and each channel (visible, infrared, water vapor). In order for a superob to be formed, the u-component, v-component, and total wind speed for all observations within a radius of 120 km must be within 5 m/s of each other, after any outliers are rejected. A minimum of two observations are required to form a superob, at least one of which was not used in a previous superob. An exception is made for EUMETSAT winds, which are provided on a thinned grid.

A few quality control checks are performed prior to computing superobs. All observations are required to have valid times, latitudes, longitudes, and pressures. Low-resolution EUMETSAT winds are not used. Winds with pressures above 100 mb or below 1025 mb are rejected, as are visible winds above 800 mb, water vapor winds below 400 mb, and infrared winds between 800 mb and 400 mb. Winds with large innovations are rejected prior to superobbing, with thresholds ranging from 8 m/s below 800 mb to 13 m/s around 250 mb. Reports with wind speeds less than 3 m/s are also rejected.

## 3. EXPERIMENTS

In order to assess the relative importance of aircraft and satellite-derived winds, a series of experiments were devised. In contrast to the "data-addition" methodology used in Graham et al. (2000), the present study uses a "data subtraction" methodology. The control experiment uses all available data. The "NO-ACFT" experiment uses the same data, but excludes aircraft data. The "NO-SATW" experiment, similarly, uses all data except satellite feature-track winds. Finally, the "AC+SATW" experiment excludes satellite feature-track winds, but only in regions where aircraft winds are present. This final experiment was set up to test a methodology similar to that used by the Japan Meteorological Agency, where they assume aircraft winds are better able to depict the wind speed maxima associated with jet streaks as well as the associated horizontal and vertical shears. This experiment will test whether aircraft winds should be given precedence over satellite winds in NAVDAS.

## 4. REFERENCES


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