Universität Trier
Umweltmeteorologie
Environmental Meteorology

A low-cost approach to derive upper-air wind measurements from ADS-B

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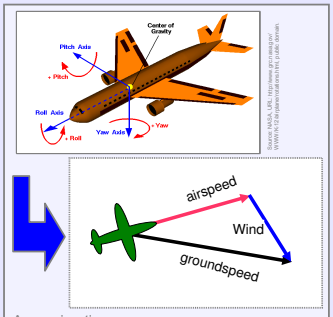
Motivation

Using navigation data of aircraft to derive wind measurements is a usual practice. If only the horizontal wind is needed, as in the AMDAR (aircraft meteorological data relay) program, the calculation can be simplified significantly by assuming that the flow is parallel to the aircraft body. Then, only the aircrafts heading and true airspeed (measured by the speed indicator) as well as its ground speed (from the change of the aircraft position) are required (Fig. 1).

Our approach is to use extremely affordable equipment (250$) to collect ADS-B transmissions. If an airport used by ADS-B-equipped aircraft is within the range of the receiver, this method allows to generate wind profiles even in radar-sparse areas. We hope that this approach will help to fill more "white spots" of worldwide upper air data coverage (Fig. 2).



Approximations:
- zero vertical wind
- roll angle small or zero
- zero sideslip and zero pitch

Fig.1: simplified wind calculation

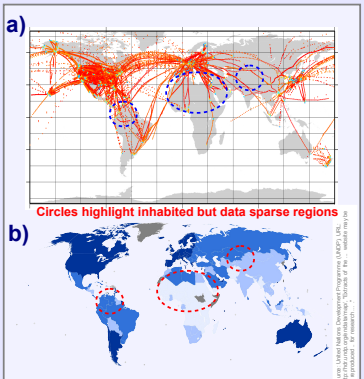


Fig.2: AMDAR data coverage (2012-12-01; a) and Human Development Index (UNDP, 2013; b).

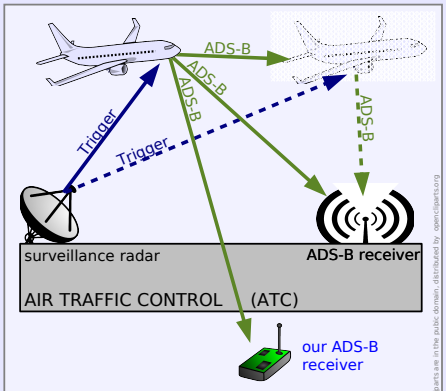


Fig.3: ADS-B (Automatic Dependent Surveillance - Broadcast): data flow scheme

ADS-B

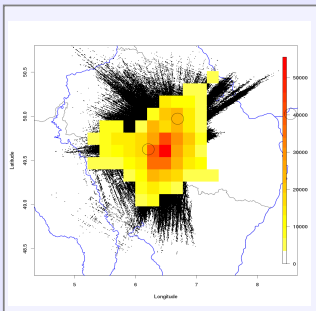
Automatic Dependent Surveillance - Broadcast offers the same navigation information, i.e. frequent reports of airspeed and heading and position reports every few seconds, via the aircraft by transponder (extended squitter) radio broadcast. Dutch weather Service (KNMI) has demonstrated that high-quality wind measurements can be derived taking airspeed supplied via ADS-B together with groundspeed determined by tracking and ranging radar (TAR-1) at Amsterdam Schiphol (EHAM) airport (de Haan, 2011).

First results

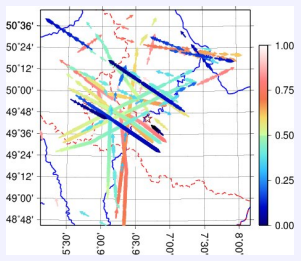
Different hardware configurations have been tested. Discarded old PC as well as new micro-PC (Fig.4) were both successfully used. A digital TV (DVB-T) receiver USB-stick stick was used with gnuradio extension "modes". Typically, a gain of 32dB had to be used, but was not available on all tested DVB-T receiver models.

Using an off-the shelf antenna (Fig.4) on a roof yields typically 200.000 ADS-B reports from around 1000 aircraft per day. The typical range is 70 km (in a low-mountain region, Fig.5). Using a dedicated 1090 MHz roof antenna roughly doubles the number of data.

In contrast to the study by de Haan (2011), we use solely data supplied via ADS-B. Since the contained position information is more coarse than that derived from terminal radar, the raw wind values exhibit a larger scatter (typ. 27%), compared to the KNMI method. A smoothing algorithm for ADS-B position is currently being developed and the outcome is compared to rawinsonde soundings and AMDAR data.



a) data points are overlaid by color in case of >10³ data per tile



b) color indicates data point point age

Fig. 5: Typical weekly (a) and hourly (b) data overage around Trier, Germany. Rivers plotted blue, borders black or red, resp.

References

de Haan, S. (2011) 'High-resolution wind and temperature observations from aircraft tracked by Mode-S air traffic control radar ' J. Geophys. Res., 116 AGU, D10111 doi: 10.1029/2010JD015264

Lenschow, D. (1972) 'The measurement of air velocity and temperature using the NCAR Buffalo aircraft measuring system ' National Center for Atmospheric Research, 48pp.

UNDP - United Nations Development Programme (2013) 'Human Development Report 2013' United Nations Development Programme, New York, NY, USA, 216pp.