AIRBORNE DOPPLER WIND LIDAR INVESTIGATIONS OF WESTERN PACIFIC TYPHOON GENESIS AND EVOLUTION

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1. INTRODUCTION

During August and September, 2008 the NSF and ONR co-funded research in the western Pacific (TPARC[1] and TCS08[2]) to improve our understanding of typhoon genesis and evolution. The major components of that field experiment included several aircraft equipped with dropsondes, Doppler radar and two Doppler Wind Lidars(DWL). One lidar was flown on the German Falcon aircraft and the other was flown on a Navy's P3. It is the latter DWL that is discussed briefly here. Most of this presentation will be on the data that was collected and initial efforts to evaluate their potential impact on tropical cyclone forecasting.

Airborne DWLs have a history dating back to the late 1970's. Those early systems were used to study clear air turbulence, convective clouds, and boundary layer winds (jets and complex topography flow). Until the TPARC field campaign, there had not been a concentrated effort to devote ~100 flight hours on one significant atmospheric phenomena. In addition to the science objectives of TPARC, the DWL on the Navy P3 (P3DWL) was used to collect data using flight patterns that were suited to conducting representativeness studies associated with sampling from a future space-based DWL (Baker, et al, 1994).

2. INSTRUMENTATION

The P3DWL uses the latest version of a coherent Doppler transceiver developed at Lockheed Martin Coherent Technologies. The lidar, with the exception of the scanner, is shown on the left in Figure 1. The scanner is shown on the right in Figure 1. The scanner is a bi-axial scanner that enables pointing the beam in any direction within a +-30 degree azimuth window and +- 120 degree elevation window. This scanner design was critical to the success of the DWL's participation in TPARC.

Both a dropsonde system and the NCAR[3] ELDORA radar were flown along with the P3DWL. The dropsondes provided wind profiles for comparisons with the DWL wind profiles with spacings of ~ 50 km. The P3 DWL was scanned to produce soundings every 2 -3 km.

Figure 1. The P3DWL instrument rack is shown on the left and the biaxial scanner is shown on the right along with a fairing form reducing turbulence and drag.

3. DATA DESCRIPTION

The lidar was configured to operate at ~ 100 HZ with a recorded range-of-regard of 4000 meters. The range is resolved to 50 meters with minimal overlap. Since the coherent lidar depends upon atmospheric aerosols for its return signal, the vertical cover varies from one situation to another. In general, however, the convection and high winds associated with typhoons provided ample aerosols and thus profiles from flight level (usually 3km) to the surface were common. In fact penetration through cloud layers exceeded expectations and thus suggested that optical systems such as the P3DWL are better suited for cloudy target regions than may have been assumed.

The most common scanning sequence used to direct the lidar beam was a 12 point step-stare (20 degree off nadir cone angle) followed by a 5 second nadir stare. This pattern was repeated throughout the flight unless a decision to profile above the aircraft was made. The dwells at the stare angles were 1 second allowing more than 100 individual shots to be combined to produce a single Line-of Sight (LOS) at 12 perspectives. Several processing techniques combined the 12 looks to get a full vector (U,V, W) wind corrected for aircraft motion and attitude (roll,pitch,yaw).

In Figure 2 examples of a single profile along with a curtain of profiles near the eye of typhoon Hagupit (2008) are provided.

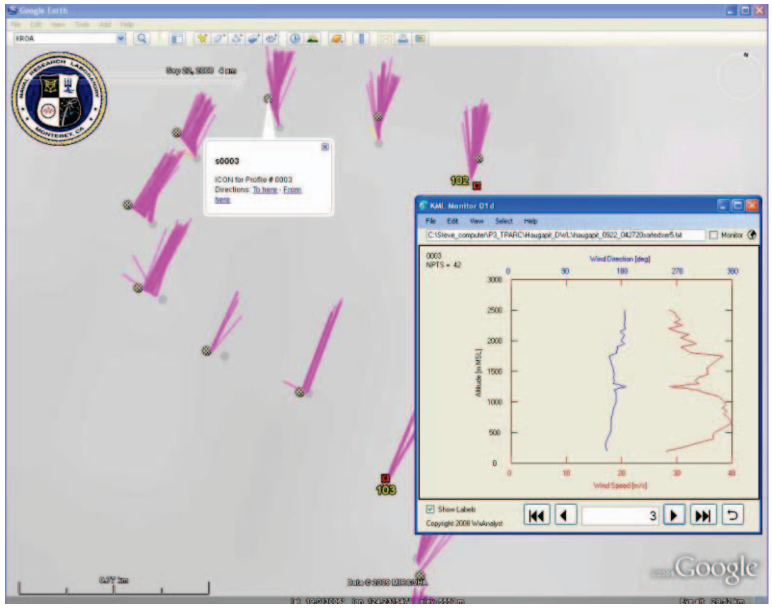

Figure 2. Ten wind profiles near the eye of typhoon Hagupit expressed with wind barbs are shown along with a single profile of the winds shown in the inset.

4. DATA IMPACT ANALYSES

At the time of submission for this abstract, preliminary impact studies are underway. The initial effort involves the use of the P3DWL wind profiles along with the WRF model being run at the University of Utah to examine the potential impact of airborne lidar wind profiles on typhoon forecasting. An example of such a case study is provided in Figure 3.

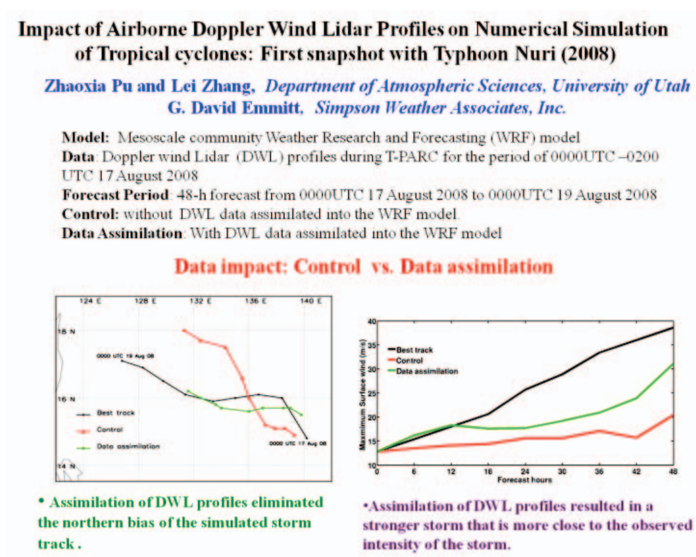

Figure 3. A slide reproduced from a presentation on the impacts of the P3DWL wind data on a WRF forecast of typhoon Nuri (2008).

5. SUMMARY

In general, the P3DWL flown on a Navy P3 in TPARC demonstrated a significant new source of data for the study and forecasting of tropical cyclones. The lidar provided far more complete vertical soundings within the cloudy environment of typhoons than was expected. The accuracy of the wind vectors met all expectations and must be considered more reprehensive than the dropsondes. However, the dropsondes are valuable for the temperature and moisture information they provide.

There are extensive funded efforts to establish the accuracy and utility of the data collected on four major typhoons during TPARC.. Also the data is being used to address issue of representativeness of the widely space samples expected from future space-based DWLs. In the near term, plans are in place to fly two or more DWLs in 2010 during the hurricane research with airborne DWLs for the next 5 years. All of this airborne DWL activity is being done with the expectation of under flying the ESA[4] ADM[5] planned for launch within the next year or so.

6. REFERENCE

Baker, W.,E., G.D. Emmitt, P. Robertson, R.M. Atlas, J.E. Molinari, D.A. Bowdle, J. Paegle, R.M. Hardesty, R.T. Menzies, T.N. Krishnamurti, R.A. Brown, M.J. Post, J.R. Anderson, A.C. Lorenc, T.L. Miller and J. McElroy, 1994: Lidar measured winds from space: An essential component for weather and climate prediction. Bull. Amer. Meteor. Soc., 76, 869-888.

7. ACRONYMS

1. TPARC: Thorpex Pacific Asian Regional Campaign
2. TCS08: Tropical Cyclone Study 08
3. NCAR: Nation Center for Atmospheric Research
4. ESA: European Space Agency
5. ADM: Atmospheric Dynamics Mission