

# **ATMOSPHERIC DENSITY CURRENTS: IMPACTS ON AVIATION OVER NSW AND ACT**

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Submitted in fulfilment of the requirements for the degree of  
Doctor of Philosophy

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[2019]

# Statement of Original Authorship

## CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Shuang Wang declare that this thesis, is submitted in fulfilment of the requirements for the award of PhD, in the School of Mathematical and Physical Sciences at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

Production Note:

Signature: Signature removed  
prior to publication.

Date: 06-Oct-2019

# Keywords

ACT, Aviation, Canberra, climate, cooler, damaging winds, density current, down burst, microburst, NSW, observations, permutation testing, ranges, Rossby waves, satellite images, short-lived gusty winds, southerly busters, squall lines, Sydney, thunderstorms, turbulence, warnings, wavelet analysis, wind shear (in alphabetical order)

# Abstract

Three main types of density currents (DCs) which have significant impacts for aviation are investigated in detail over New South Wales (NSW) state of Australia and Australian capital Territory (ACT) in the research. The three types of density currents are southerly busters (SBs) along the coastal NSW, thunderstorm downbursts over north-western NSW and easterly DCs over Canberra.

The research take advantage of the recently available Himawari-8 high temporal- and spatial-resolution satellite data, Sydney wind profiler data, Doppler radar data, radiosonde data, half hourly METAR and SPECI aviation from observation data Bureau of Meteorology Climate zone, synoptic weather charts and other observational data. In addition, simply model for density currents, global data assimilation system (GDAS) meteorological model outputs, and the Australian Community Climate and Earth-System Simulator (ACCESS) operational model products are employed in the research.

Based on the impacts on aviation, for SBs and strong SBs (SSBs), when wind directions are between 160 degrees to 210 degrees, SBs are the average winds or gusty wind is  $\geq 14.9$  m/s (29 knots or 54 km/h), SSBs are the average winds or gusty winds more than 20.5 m/s (40 knots or 74 km/h). For easterly DCs, when wind directions are between 070 degrees to 150 degrees, the average winds or gusty wind is  $\geq 7$  m/s (13 knots or 23 km/h). For thunderstorms downbursts, damaging winds are the average winds or gusty winds more than 20.5 m/s (40 knots or 74 km/h) in any direction.

The results of this research show that the data analyses support the widespread view that the SB is a DC, coastally trapped by the Great Dividing Range. In addition, solitary waves develop ahead of SB in a shallow and stable prefrontal boundary layer.

A simplified density current model is applied to SBs, SSBs and easterly DCs. The model results have been verified by the observations. The results that are solely model based also suggest that the solitary waves travel at speeds about 20% faster than the DCs which is consistent with the high-resolution satellite data and shows the solitary waves moving increasingly ahead of the leading edge of the DCs.

The damaging winds caused by thunderstorm downbursts are DCs. The characteristics are presented, and forecast parameters and indices are discussed.

Finally, the climatological trends for SBs and SSBs at Sydney airport are examined statistically by using permutation testing and wavelet analysis. The results show that there is significant increase in SBs over last 49 years, however, the SSBs show no significant trend over the same period.

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# List of Abbreviations

ACCESS	Australian Community Climate and Earth-System Simulator
AEDT	Australian Eastern Daylight Time
AP	Airport
ATC	Air Traffic Control
AWS	Automatic Weather Station
CAPE	Convective Available Potential Energy
CAVOK	Sky and visibility OK
CDT	Coastal Trapped Disturbance
DC	Density Current
DMAPE	Downdraught Maximum Available Potential Energy (DMAPE)
GDR	Great Dividing Range
GDAS	Global Data Assimilation System
GPATS	Global Position and Tracking Systems
HAM	Highest Alternate Minima
ICAO	International Civil Aviation Organization.
MCS	Mesoscale Convective System
METAR	Routine weather report issued at hourly or half-hourly intervals.
NSW	New South Wales
NWP	Numerical Weather Prediction systems
QNH	A Q code indicating the atmospheric pressure adjusted to mean sea level. It is a pressure setting used by pilots, air traffic control (ATC).
SB	Southerly Buster
SC	Southerly Change
SIGMET	Significant Meteorological Information AIM 7-1-6
SPECI	Special weather report issued when there is significant deterioration or improvement in airport weather conditions
SSB	Strong Southerly Buster
TAF	Terminal Aerodrome Forecast
TTF	The Trend Forecast
UTC	Coordinated Universal Time

# Acknowledgements

I thank the Australian Bureau of Meteorology for providing the data used and the work experience in this study. The study also was partially funded by the Australian Technology Network's Industry Doctoral Training Centre (IDTC). The PhD study was carried out at the School of Mathematical and Physical Sciences at the University of Technology Sydney, after originally starting at RMIT.

Firstly, I would like to express my sincere gratitude to my advisors' panel: Prof. Tapan Rai, Lance Leslie, Yuriy Kuleshov for the continuous support of my PhD study and related research, for their patience, motivation, and immense knowledge. Their guidance helped me in completing the research and writing of this thesis. I could not have imagined having better advisors and mentors for my PhD study. Particularly, I express my gratitude to Prof. Lance Leslie who always enlightens my interests on the research topic with his passion for research. Besides my advisors, I would like to thank the rest of my thesis committee: Prof. Kefei Zhang Prof. Tim Langtry, Prof. Murray Cameron, A/Prof. Yakov Zinder, Dr. Milton Speer, Dr. Yan Ding, Dr. John Gear, Dr. Suqin Wu, Dr. Sally Cheng and PhD student Joshua Hartigan for their insightful comments and encouragement, but also for the hard questions which encouraged me to widen my research interests.

Also, I thank my colleagues in the Regional Forecasting Centre of Bureau of Meteorology for their stimulating discussions, for the sleepless nights we were working together and for enlightening me the first glance of research.

Last but not least, I would like to thank my family: my husband, my son and my parents for supporting me spiritually throughout writing this thesis and my life in general.