TRIGGERING OF DEEP CONVECTION BY LOW-LEVEL BOUNDARIES

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I. INTRODUCTION

Southern Africa is a region that frequently experiences thunderstorms, particularly in the summer months over the central and eastern parts of the region. Many of these storms can be severe (as per NSSL definition), posing a distinct threat to life and property (Pyle, 2006). Rural communities are often at risk from flash-flooding, lightning, hail and wind damage (be it tornadic or non-tornadic in nature).

Accurate, appropriate and timeous nowcasts (lead-time on the scale of a few minutes to no more than a few hours) are desirable for any weather agency. The pursuit of any methodology or knowledge which could be applied in practice, to mitigate the destructive and adverse effects of such storms, should be an ongoing, high-priority activity of a modern weather service.

In South Africa in recent years, the role of remotely-sensed meteorological data (particularly from satellite and radar sources) in the diagnosis and monitoring of severe thunderstorms has been significantly elevated. This is especially true in the case of Meteosat 9 (previously MSG) data and in particular, RGB composite images. In a (meteorologically) data-sparse domain such as South Africa, the judicious and effective use and interpretation of radar and satellite data is critical if forecasters are to perform robust and sustainable storm monitoring activities countrywide.

Low-level boundaries are a well-documented and common triggering mechanism for deep convection in general, Weckwerth & Wakimoto (1992), Wilson & Roberts (2006), Wilson & Schreiber (1986), Wilson, *et al.*(1992), Schreiber-Abshire (2003). The landmark southern hemisphere case study by Sills, *et al.* (2004), regarding tornadic storms during the Sydney 2000 Olympic Games, confirms the role that boundaries (including thunderstorm outflow interaction with sea-breeze fronts) played in triggering severe storms. Rasmussen, *et al.* (2000) highlights and investigates relationships between tornadic storms and boundaries. Dial & Racy (2004) discuss forecasting aspects, in the context of the challenge forecasters face when trying to anticipate possibly severe interactions between storms and boundaries.

II. PRESENTATION OF RESEARCH

The author's study represents a body of work in progress and is being approached in phases, as partial requirements for MSc study at Pretoria University. The supporting literature study is complete, with attention now shifting to the collection of suitable field case studies during the southern hemisphere summer of 2009/2010.

This study aims to synchronise and integrate established literature (regarding low-level boundary interactions with thunderstorms) with local (southern African) operational nowcasting practise.

Standard Meteosat 9 channels as well as EUMETSAT RGB combinations (such as 'FOG A', 'Day Microphysical' and 'Dust') are to be used as *diagnostic tools* to identify incipient thunderstorm outflows (with respect to both diurnal and nocturnal cases), whilst Doppler S and X-band RADAR data will be utilised to monitor and quantify subsequent convective development deemed to have been triggered or influenced by such outflows. As an ancilliary remote-sensing assessment tool (in terms of assessing possible storm severity in a southern African domain (Rae & Clark, 2005)), the EUMETSAT 'Deep convection/ overshooting tops' RGB will be used to supplement RADAR data.

A multi-sensor approach, utilising a variety of meteorological sensing equipment will be employed. Multiple overlays of satellite, RADAR as well as Vaisala LDN lightning data will be viewed and manipulated with the use of SUMO visualisation software as well as via a NinJo meteorological workstation. Direct measurement of surface meteorological variables (by surface AWS and Vaisala AWOS) at a high temporal rate (5min or less) of particularly air temperature and pressure are critical in order to discriminate between a gravity wave disturbance and that of a density current flow (Kingsmill, 2003), Haertel, *et al.*, (2000).

Vertical measurement of the lower layers (surface to about 3km AGL) of the troposphere will be performed using a combination of Vaisala RS92-SGP radiosonde balloon soundings as well as *in situ* aircraft measurements in the form of GPS-referenced AMDAR reports from commercial airliners. In particular, aircraft takeoff and approach profiles for Oliver Tambo International Airport (ORTIA), near Johannesburg, occur at short intervals with only 5 to 10 minute separation (per flight) and are a valuable nowcast and research-quality data source. The accuracy of AMDAR reports has been found to be comparable to the high performance and accuracy of traditional radiosonde instruments (Drue *et al.*, 2008). Radiosonde and AMDAR data, being GPS-referenced, as well as containing altitude data, are well-suited to 3-D spatial representation (eg. Google Earth) and it is hoped that new and innovative ways of presenting data spatially may well lead to additional insights being gained during the course of this study.

III. RESULTS AND CONCLUSIONS

During 2008/2009, preliminary assessment of the viability of Meteosat 9 (MSG) data to identify and track low-level boundaries has been quite successful. It has been very encouraging to establish that the EUMETSAT "FOG A" RGB (which incorporates IR 3.9 µm information) lucidly picks up fine-scale structure, clearly demarcating the leading edge of outflow boundaries. Similarly, for diurnal applications, the EUMETSAT "Day Microphysical" RGB is equally useful, as is the "Dust" RGB. In last-mentioned case, a useful (if indirect) means of establishing the presence of an outflow boundary (given arid, dusty environments, typical of central and western South Africa) is to identify billowing dust plumes rising up on the leading edge of the boundary (Kerkmann *et al*, 2004). Naturally, the high-resolution VIS channel is also invaluable for diurnal monitoring of the evolution of outflow and potential subsequent triggering of deep convection.

Further cautionary insight has been the realisation that *gravity wave* disturbances often manifest themselves in superficially similar ways to that of *density currents*. The value and role of traditional surface meteorological data (especially pressure and temperature) at a high temporal resolution is thus confirmed as a critical component of the author's study design. The selection and screening of potential case studies will almost certainly require confirmatory surface AWS and/or AWOS data. Kingsmill (2003, 2985-2986) gives a clear description of the meteorologically measurable discriminatory (surface) features between the two phenomena, as does Haertel *et al*., (2001).

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