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QUIKSCAT ANALYSIS OF MARINE ATMOSPHERIC FRONTS

Jérôme Patoux * and Robert A. Brown
University of Washington, Seattle, Washington

1. INTRODUCTION

Atmospheric fronts have been studied with analytical models, numerical simulations and global analyses (Orlanski et al., 1985). Recently, several experiments have incorporated high-resolution measurements to numerical data sets in an attempt to capture the dynamics of fronts as they develop, intensify, decay or sometimes give birth to a new frontal wave. Significant improvements in our understanding of frontal development have spawned from such experiments as FASTEX in the North Atlantic (Mallet et al., 1991) and observation programs in the Australasian region (Reeder and Smith, 1998). However these experiments were limited to specific geographic regions.

Since July 1999, the SeaWinds-on-QuikSCAT (QS) scatterometer has been providing us with dense, high-resolution measurements of the surface winds over the world ocean. The surface structure of marine atmospheric fronts can be studied and reveals complex features such as 4000-km long trailing cold fronts, double cold fronts or the so-called "T-bone". With a 1700-km-wide swath and a 25-km grid-spacing, QS offers an unprecedented look at the marine surface wind field.

Here QS surface winds and a kinematic approach are used to analyze fronts at each stage of their development and to build a history of frontogenesis and cyclogenesis (or frontal wave development).

2. TOOLS AND IMAGES

The tools developed by Patoux and Brown (2001, 2002) are used to compute surface pressure fields from QS surface wind measurements and to correct the winds for errors due to rain contamination and to the geometry of the antenna. The divergence and vorticity of the corrected surface winds are then calculated. Infrared satellite imagery for the period of interest was obtained from the Global Hydrology Resource Center (GHRC). By plotting the divergence and the surface pressure for a series of adjacent swaths, along with the closest-in-time infrared satellite image, three different views of a synoptic system are obtained. By iterating at each pass of the satellite (roughly 12 hours), a history of the development of that system is obtained. An example is shown in figure 1, where a major cyclone is seen to decay South of the Drake Passage, leaving behind a trailing cold front (panel a). The front is clearly identified as a strip of convergence (plotted in red in the left-hand column - see scales on figure 2), a trough in the pressure field with the corresponding change in the curvature of the isobars across the front (middle column), and has furthermore a clear cloud signature in the infrared satellite image (right-hand column).

The 5 lines of plots in Fig. 1 are separated roughly by 12 hours. In 48 hours, the front has given way to a fast-developing cyclone, appearing as a "textbook" comma in both the divergence field and the cloud field. It is reminiscent of the frontal waves observed in the North Atlantic (Parker, 1998). Such phenomena are observed repeatedly in the Southern Hemisphere and reflected in the kinematics of the QS winds.

3. PARTITIONING OF THE WIND

The technique described by Bishop (1996a) was adapted to QS surface wind measurements to diagnose the impact of the environmental flow on the development of the front. A box is drawn around the front in such a way as to enclose all the vorticity and divergence characterizing the front. A

* *Corresponding author address:* Jérôme Patoux, Univ. of Washington, Dept. of Atmospheric Sciences, Seattle, WA 98195-1640; e-mail: jerome@atmos.washington.edu

non-divergent and an irrotational wind fields are attributed to these elements of vorticity and divergence. The environmental flow is obtained by subtracting them from the total wind. An example of such a partition is shown in figure 2. In panel (a), the pressure field shown in figure 1a has been rotated in such a way as to align the front with the page and the frontal box has been drawn. Panel (b) is an enlargement of the frontal box showing the QS surface winds and their divergence The non-divergent and irrotational components of the wind field are shown in panels (c) and (d) respectively. The “harmonic” or environmental flow is shown in panel (e).

4. IMPACT OF THE ENVIRONMENTAL FLOW

The harmonic wind field is seen to induce strong deformation along an axis that lies at an angle with the front. The front is thus effectively “stretched” and rotated by the environmental flow. Theoretical considerations and calculations using numerical analyses and observations suggest that the development of frontal waves such as the cyclone observed in figure 1e is dependent upon a decrease in stretching deformation along the front (Bishop, 1996b; Rivals et al., 1998; Renfrew et al., 1997). These ideas can be tested here with measured surface winds.

5. CONCLUSION

The advent of scatterometers offers an unprecedented opportunity to study the development of fronts and frontal waves over the world ocean. Kinematic approaches can be applied directly to measured surface winds and compared with theoretical results. Detailed analyses are available at pbl.atmos.washington.edu.

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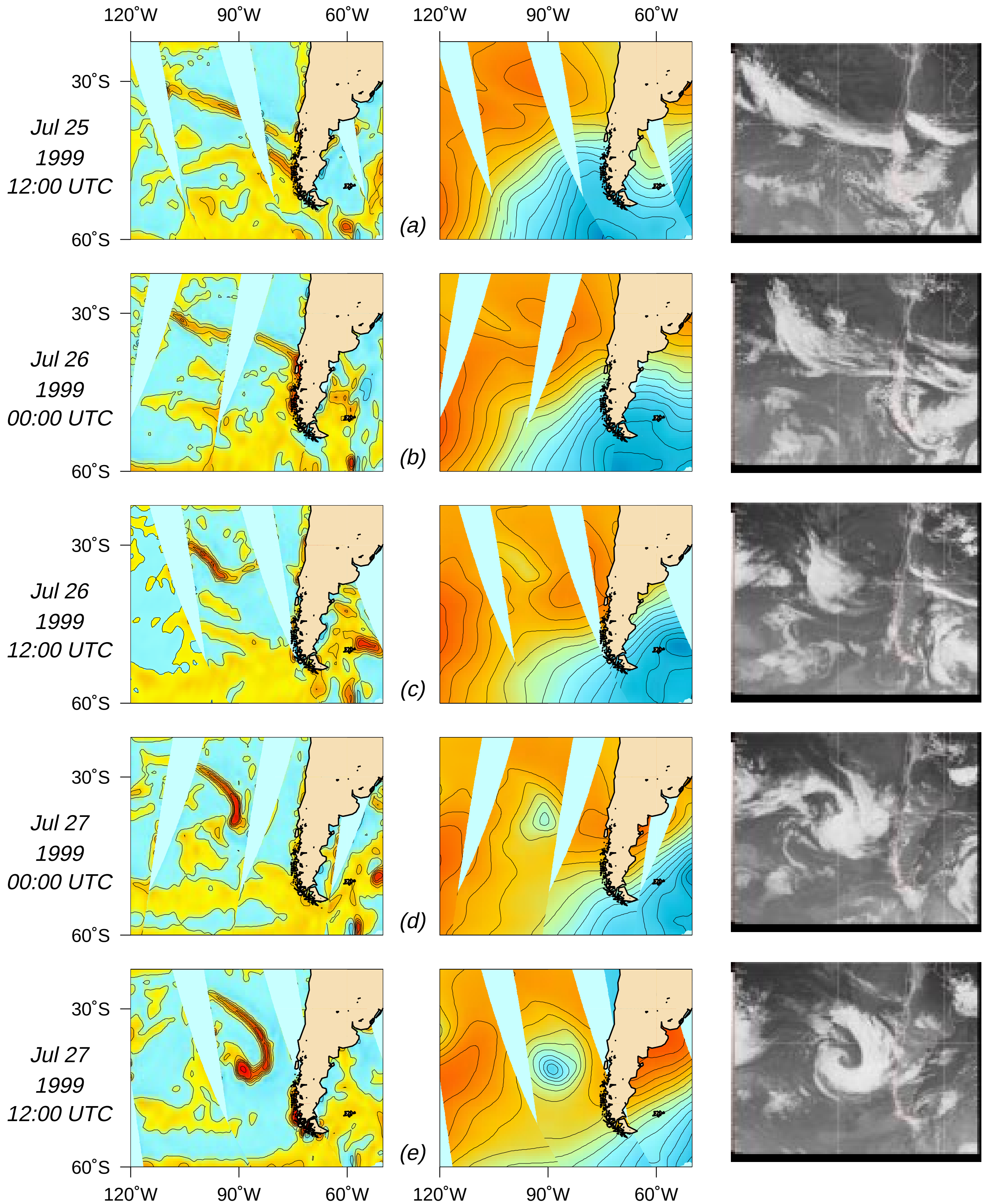

Figure 1: Frontal development over the Southern Pacific Ocean - July 1999 (see scales on figure 2)

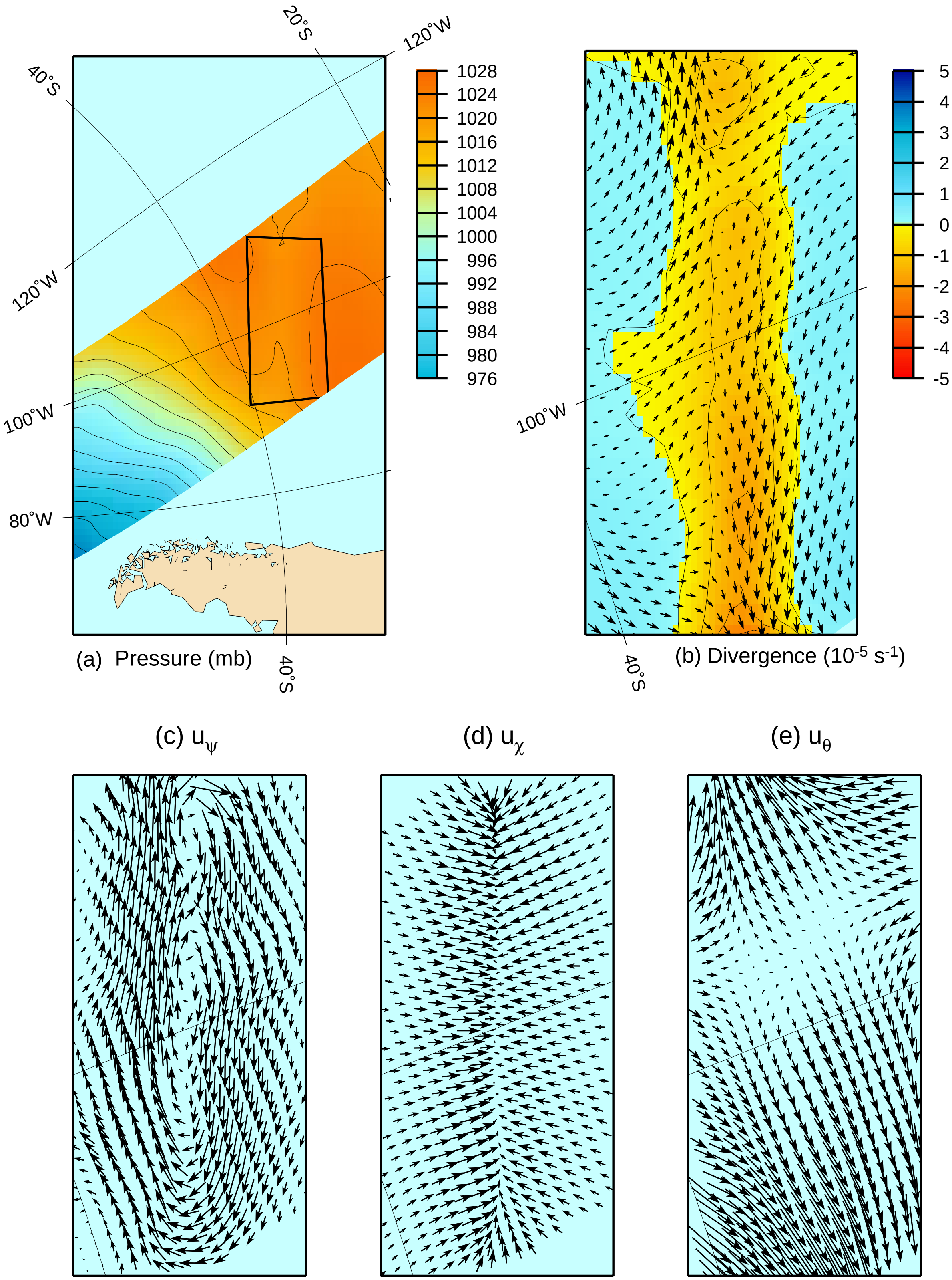

Figure 2: Partitioning of the wind in a frontal box