FIG. 1. Cloud formation allows visualization of the overturning motion associated with a rotor. (Digital webcam photograph taken from Mount Pleasant Airfield on East Falkland Island.)

ducted a field experiment aimed at measuring the near-surface flow over the Mount Wickham range in the Falkland Islands. The measurements indicate that severe downslope winds and leeside turbulence at the surface, associated with lee wave rotors aloft, can be linked to the presence of a strong temperature inversion (temperature increasing with height) near

FIG. 2. An automatic weather station used on East Falkland.

the mountaintop height.

The experiment focused on Mount Pleasant Airfield, south of the Wickham range. When the wind is northerly, flights there are frequently hampered by low-level turbulence associated with lee waves, termed "rotor streaming" by forecasters (Fig. 1). A primary aim of the project was to develop practical rotor forecasting tools.

The field observations consisted primarily of an array of 20 automatic weather stations (see Fig. 2), which measured wind (at 2 m), temperature, humidity, and surface pressure. The latter measurements were made using sensitive microbarographs. The weather stations were arranged in a transect oriented roughly normal to the Wickham ridge, with a dense cluster located across the airfield.

In northerly flow, the instruments recorded periods of strong leeside wind acceleration at the airfield and instances of pronounced wind variation across

the airfield indicative of rotors above. Radiosonde measurements then allowed the degree of flow acceleration and variability to be related to the vertical profiles of wind and temperature. Specifically, empirical relationships have been established between the downwind acceleration (and variability) and the low-level stratification and upstream wind speed. We have also examined the impact of an upstream temperature inversion on the flow by creating a flow "regime diagram," which summarizes how flow types (regimes) are differentiated according to the strength and height of the upstream inversion and the upstream wind speed. Results such as these may be useful in developing methods for forecasting rotors and strong downslope winds.—PETER SHERIDAN (MET OFFICE), S. VOSPER, AND S. MOBBS. *"Observation of Rotors and Downslope Winds in the Falkland Islands." 11th Conference on Mountain Meteorology and the Annual Mesoscale Alpine Program.*

A FINE VIEW FROM SPACE

Vast oceans are poorly observed by traditional measurements. Global climatic datasets typically have resolutions of hundreds to 1000 km, leaving shorter-scale air–sea interaction unexplored. New satellite observations are revealing rich structures of oceans and the overlying atmosphere in detail never possible before. Here we discuss a few recent examples to illustrate the great potential satellite data offer for studying air–sea interaction and climate. They include air–sea phenomena near ocean fronts and those triggered by terrain, features narrow in space and poorly resolved by traditional datasets.

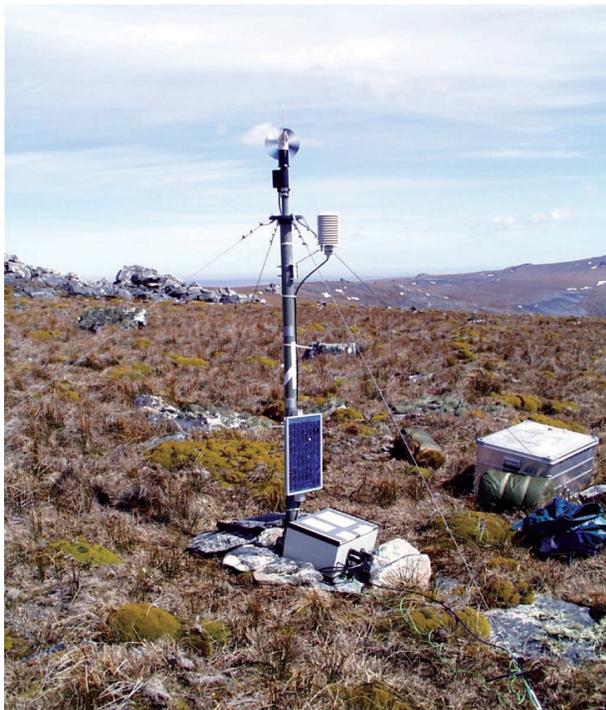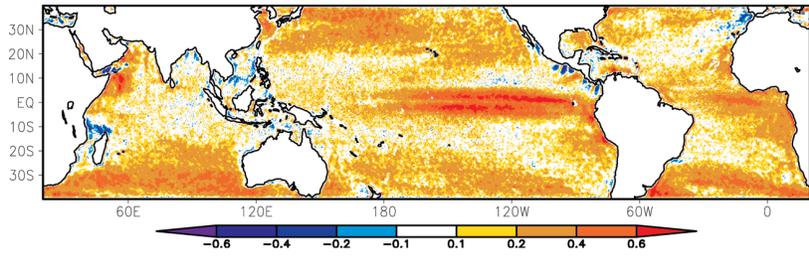Poor understanding of how extratropical oceans affect the atmo-

FIG. 1. Correlation between short-scale variations in SST and surface wind speed, high-pass filtered with 10° zonal running mean based on TRMM microwave imager observations for 1998–2002. Note that positive correlations dominate where significant SST gradients exist in the mean.

sphere is a stumbling block in recent efforts to study non-El Niño climate variability. Satellite observations reveal that sea surface temperatures (SST), winds, and clouds form a ubiquitous pattern near major ocean fronts/currents such as the Gulf Stream, Somali, and Kuroshio Currents—regions where ocean dynamics are expected to be important for SST variations. This pattern is characterized by a positive SST–wind speed correlation indicative of ocean-to-atmosphere feedback (Fig. 1). This contrasts with the negative correlation that dominates on the basin scale and is now attributed to atmospheric forcing of the ocean mixed layer. This positive SST–wind speed correlation is consistent with the vertical mixing mechanism—the near-surface atmosphere is unstably stratified on the warmer flank of SST fronts, enhancing mixing that accelerates surface winds by bringing faster winds from aloft. Recent observational and modeling studies further suggest that the effects are not limited to the planetary boundary layer but may extend over the whole troposphere by modulating storm tracks.

Another important class of air–sea interaction that satellites are beginning to reveal is that triggered by mesoscale mountainous features. Intense gap wind jets off

Central America and the Costa Rica Dome in the ocean are an example. New satellite observations show that these wind jets have a delayed effect on the atmosphere two seasons later in summer through the ocean memory in the thermocline dome. In particular,

the nearly zonally oriented Papagayo jet, most intense in winter as air rushes through a mountain gap on the border of Nicaragua and Costa Rica, is effective in forcing upwelling Rossby waves in the ocean, pushing the thermocline close to the sea surface and causing a surface cooling (Fig. 2). The cold spot over the Costa Rica Dome punches a conspicuous hole of 500 km in diameter in the summer rain band over the eastern Pacific warm pool.

With increasing computing power, global models will eventually reach sufficient resolutions to resolve narrow ocean fronts and orographic features such as the Central American mountains. When they do, short-scale air–sea interaction
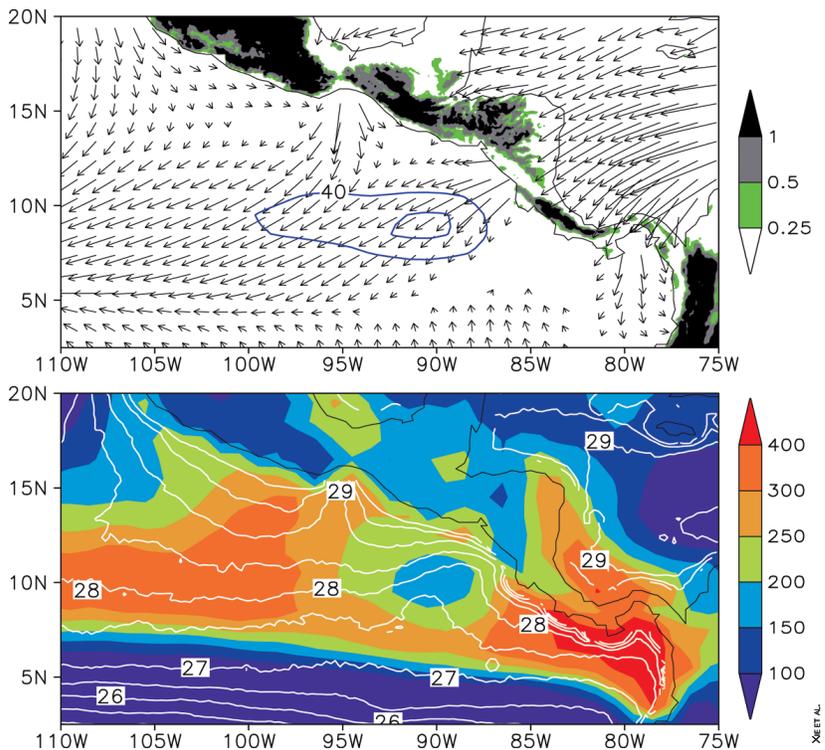

FIG. 2. Delayed effect of winter wind jets on summer climate. Upper panel: QuikSCAT pseudo wind stress (vectors in m² s⁻²) for Jan–Apr, land orography (color shade in km), and the 20°C isotherm depth for Jul–Oct (only values smaller than 40 m are plotted in blue contours at 10-m intervals). Lower panel: TRMM precipitation (mm month⁻¹) and SST (white contours, in °C) for Jul–Oct.

phenomena documented here and elsewhere will serve as a benchmark for these models to reproduce. Toward this direction, we note that the a high-resolution coupled ocean–atmosphere model run on Japan's Earth Simulator is already producing promising results.—SHANG-PING XIE (UNIVERSITY OF HAWAII), MASAMI NONAKA, YOUICHI TANIMOTO, HIROKI TOKINAGA, HAIMING XU, WILLIAM S. KESSLER, R. JUSTIN SMALL, W. TIMOTHY LIU, AND JAN HAFNER. *"Rich Structures of Air–Sea Interaction Revealed by Satellite."* 13th Conference on Interactions of the Sea and Atmosphere.

FORMATION OF SUMMERTIME SUBTROPICAL HIGHS

In each of the ocean basins, a surface subtropical high intensifies in summer, driving a subtropical oceanic gyre to form a cool equatorward current off the west coast of a continent to the east. The associated alongshore surface northerly winds act to maintain cool sea surface temperatures (SSTs) underneath by enhancing coastal upwelling and surface evaporation, favoring the development of marine stratus whose high albedo also acts to keep the cool SSTs. Thus, there seems to be a local feedback system associated with the subtropical high, but an important dynamical issue unsolved is how the high-pressure system itself is forced and maintained.

Although monsoonal convective heating has been suggested as the possible forcing, we focus on a pronounced near-surface thermal contrast observed in summer between the relatively cool eastern ocean and a heated subtropical landmass to the east. Our model experiments indicate that it is the shallow cooling/heating couplet associated with this thermal con-
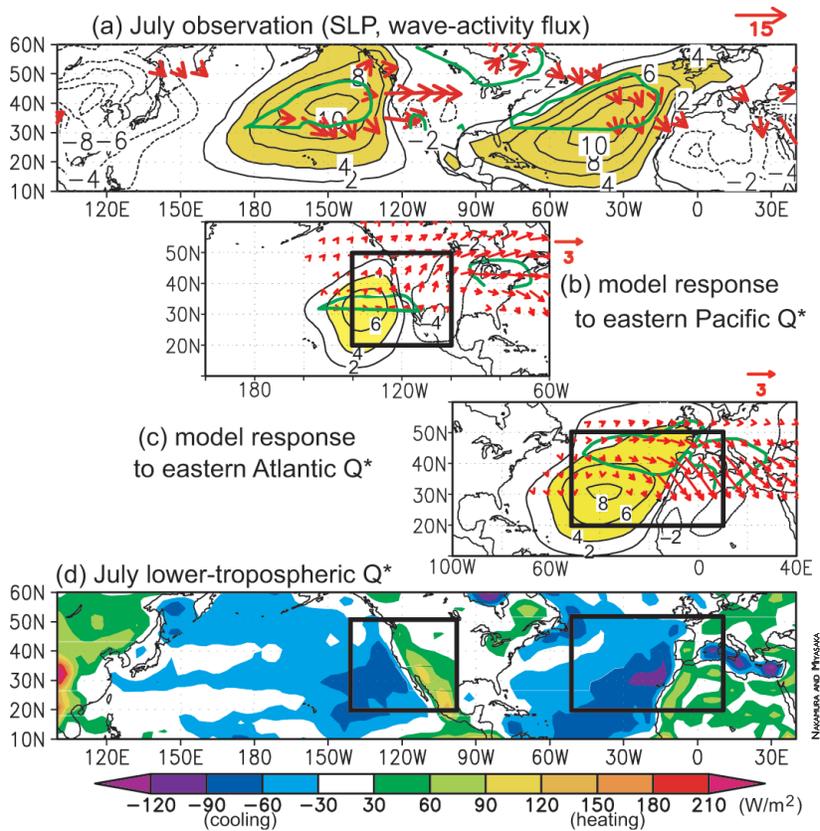

FIG. 1. (a) Zonally asymmetric component of the observed climatology of Northern Hemisphere sea level pressure (every 2 hPa; dashed for negative values) for Jul. Plumb's wave-activity flux (parallel to the local group velocity) associated with the climatological planetary waves is superimposed: red arrows [with scaling ($m^2 s^{-2}$) at the upper-right corner] for its 250-hPa horizontal component, and green lines for its 500-hPa upward component exceeding 0.01 ($m^2 s^{-2}$). (b), (c) As in (a), but for the (16–25th-day mean) response to the zonally asymmetric diabatic heating (Q^*) in the lower troposphere ($s > 0.667$) assigned only within a rectangular domain over the eastern Pacific (b) or Atlantic (c), based on a primitive equation model with its basic state fixed to the climatological zonal-mean state for July. (d) Distribution of the Jul climatology of lower-tropospheric Q^* ($W m^{-2}$) used for the model experiments (b, c), based on the NCEP–DOE AMIP-II reanalysis data.
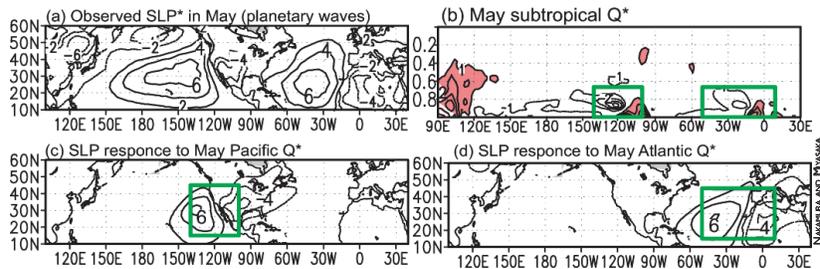

FIG. 2. (a) As in Fig. 1a, but for May. (b) Zonal section (20°–40°N) showing the May climatology of Q^* ($K day^{-1}$) (colored for heating). (c), (d) As in Figs. 1b and 1c, respectively, but for May. In (a, c, d), the wave-activity flux is omitted.