Observations and the Parameterisation of Air-Sea Fluxes during DIAMET

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The DIAMET Project

• Storms are well forecast on the synoptic-scale, but the mesoscale structures that produce strong winds and intense precipitation remain uncertain

• So we need to parameterise the key processes, including air-sea fluxes, to better understand and forecast severe storms over the UK

• Here we are using aircraft measurements at very low altitude to determine the air-sea fluxes
Aircraft Measurements

• Facility for Airborne Atmospheric Measurements (FAAM) uses a specially built BAe-146 aircraft, operated by the UK Met Office and NERC

• Able to fly at 30-40 m in strong wind

• Measures wind speed, updraft, temperature and humidity at 32 Hz (so ~3 m spatial resolution)

• Measures sea surface temperature remotely

• Now have data from 5 flights during DIAMET, plus 19 other low level flights
Calculating the air-sea fluxes

- Fluxes of momentum, sensible heat and latent heat calculated by the eddy covariance technique, using the measured high frequency perturbations.

- However NWP models require bulk fluxes that depend on wind speed at 10 m ($U_{10N}$), and the differences in temperature and humidity.

- Careful quality control was carried out on the data from each 2 minute run (~12 km) by examining the spectra and co-spectra.
Eddy Covariance Fluxes

Momentum Flux \( (\tau) = \bar{\rho} \sqrt{u'w'^2 + v'w'^2} \)

Sensible Heat = \( \bar{\rho} \ C_p \ w'\Theta' \)

Latent Heat = \( \bar{\rho} \ L_v \ w'q' \)

Bulk Fluxes at 10 m from surface

Momentum Flux \( (\tau) = \bar{\rho} \ C_{DN} \ (U_{10N}-U_s)^2 \)

Sensible Heat = \( \bar{\rho} \ C_p \ C_{HN} \ (U_{10N}-U_s)(\Theta_s-\Theta_{10N}) \)

Latent Heat = \( \bar{\rho} \ L_v \ C_{EN} \ (U_{10N}-U_s)(q_s-q_{10N}) \)
Combined Flights (OSTIA Sea-Surface Temperatures)

Wind stress (N m\(^{-2}\))

\(U_{10N}^2\) (m\(^2\) s\(^{-2}\))

- B650
- B652
- B653
- B656
- B695

-- CDN = 0.001
-- CDN = 0.002

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Storm risk mitigation
Momentum flux coefficient values

• Many of the $C_{DN}$ values are significantly larger (~50%) than the estimates from algorithms developed in previous studies

• Perhaps due to the stability of the boundary layer

• Flights within unstable air (e.g. B656 and B695) produce large $C_{DN}$ values, but those within stable air (e.g. B650 and B652) produce small values
Heat flux coefficient values

• Many of the $C_{HN}$ and $C_{EN}$ values are larger (~20%) than in the previously developed algorithms
• These strongly depend on sea surface temperature
• The aircraft uses a Heimann radiometer to measure surface temperature, and in many recent flights an interferometer (ARIES) to check the Heimann
• But the 2 sets of measurements are often different and also differ from the SST values from OSTIA
Summary

- Good quality measurements have been obtained at low levels in a variety of wind speeds.
- Initial results show coefficients that are ~50% and ~20% greater at large wind speeds (>10 m/s) than those in previously developed algorithms.
- $C_{DN}$ values may depend on boundary layer stability.
- Still need to determine the most accurate SST measurements to use in the calculations.