The use of rapid repeat-pass airborne data for the determination of water velocities in near coastal environments

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Introduction - Challenges

- Near-coastal waters are highly dynamic and spatially variable environments
- Scale limitations of satellite sensors
- Adding value
- Need for suitable methods for obtaining physical quantities (e.g. velocity)
- Ocean colour/temperature, could be used as ‘tracers’ for dynamical processes
- Data are based in the ‘real world’
- Allows model parameterisation and validation

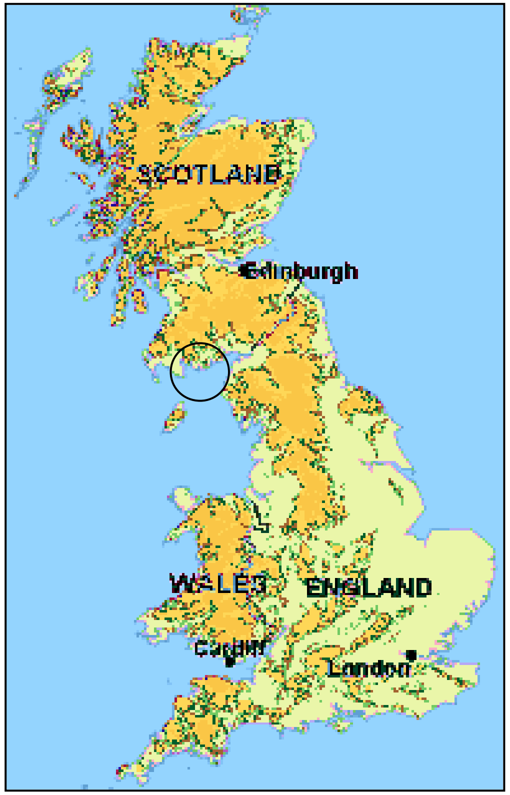
Maximum cross - correlation

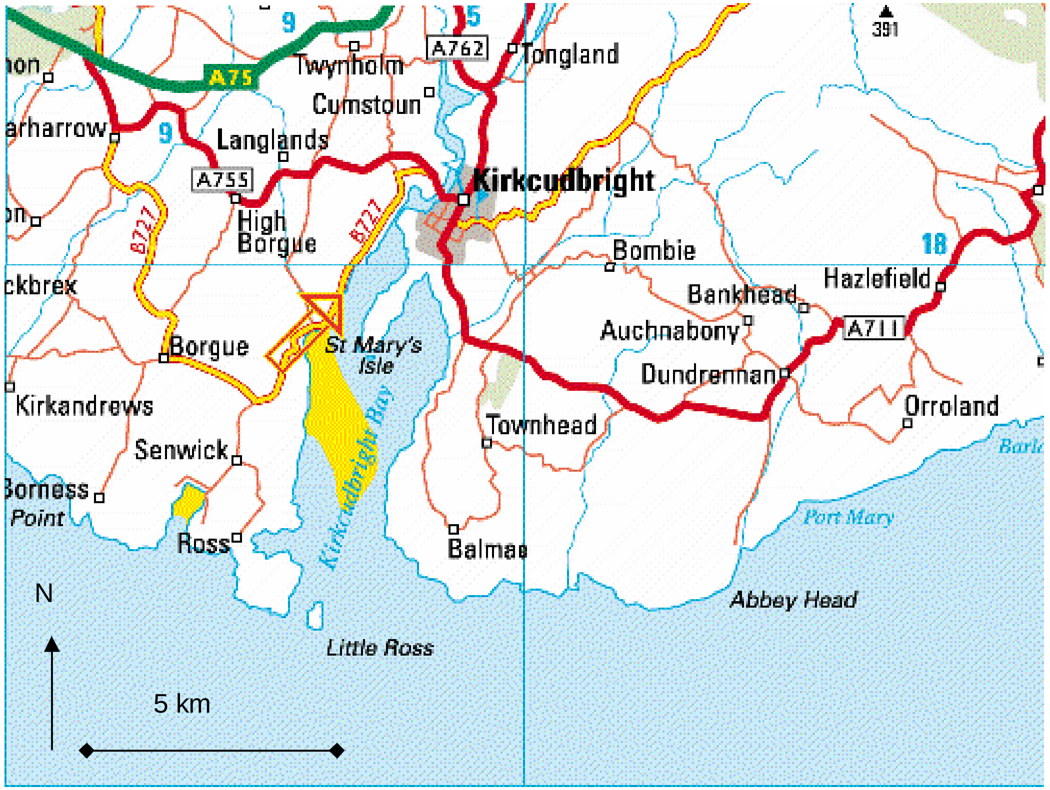
- Objective (operator independent)
- Based on cross-correlation of pattern between two sequential images
- Widely used at the meso-scale on coarse resolution imagery
- Detects translations but not rotation or deformation
- Accuracies are dependent on good geometric correction

Objective

- To evaluate the extent to which accurate and useful surface velocity maps can be derived in a turbid estuarine environment from short time-lag repeat airborne remotely sensed data

Kirkcudbright Bay, Solway Firth





Solway Firth ebb tide velocities ~ 0.4 to 0.8 m sec^{-1}

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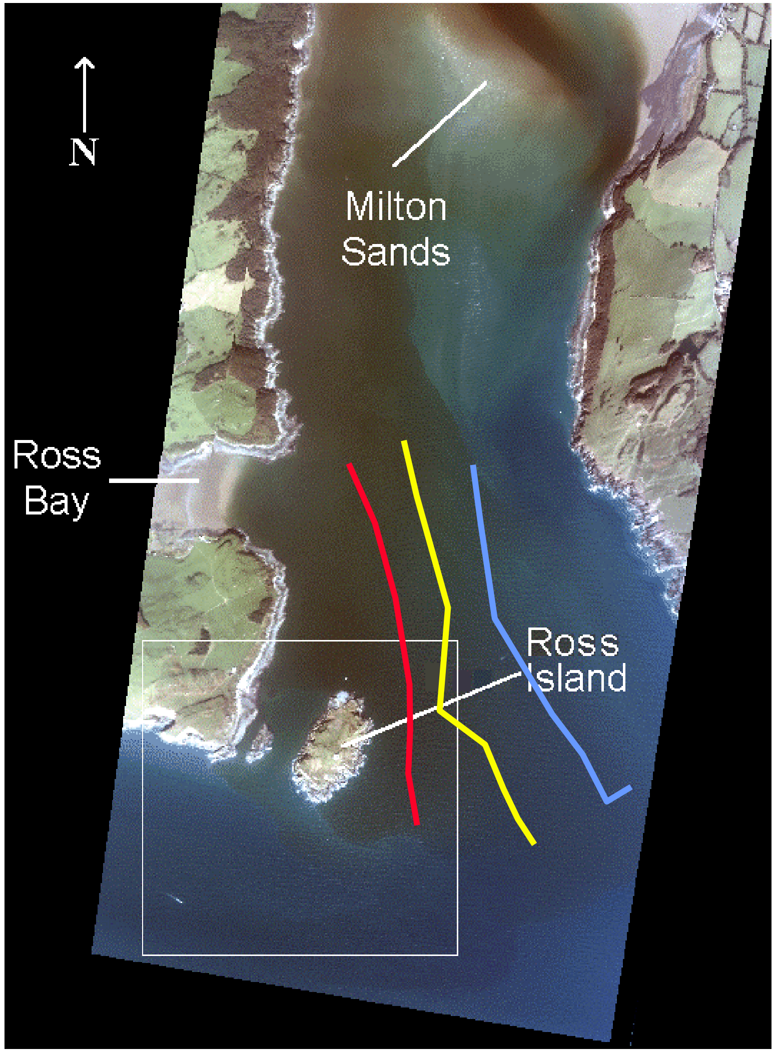
Image data collection

- Used ATM data
- May and September imaging
- Rapid, repeat-pass overflights (5 - 10 min intervals), during part of a high to low tide
- North-South direction
- 12 to 16 repeat images
- *In situ* drogue measurements (3), positioned using a Geodimeter

Drogue results



Released mid-bay ~ 10:30 am
Monitored to ~ 12:10 pm

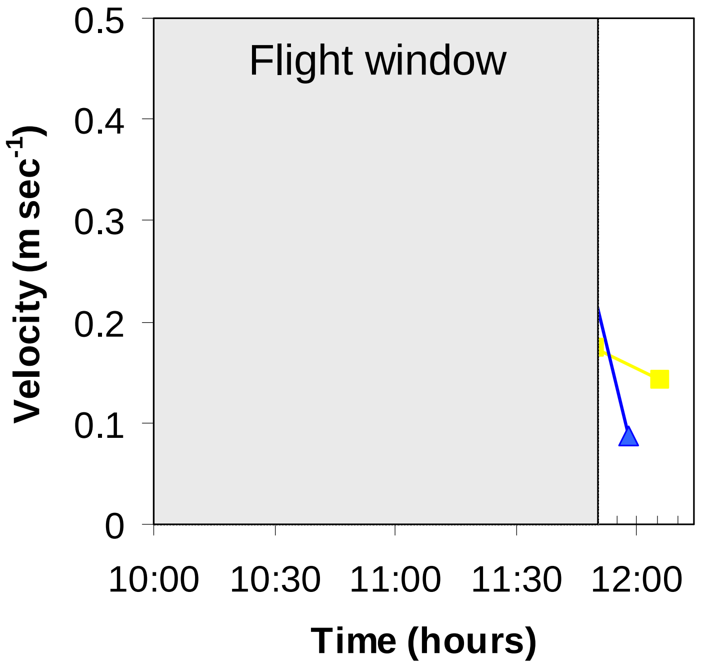


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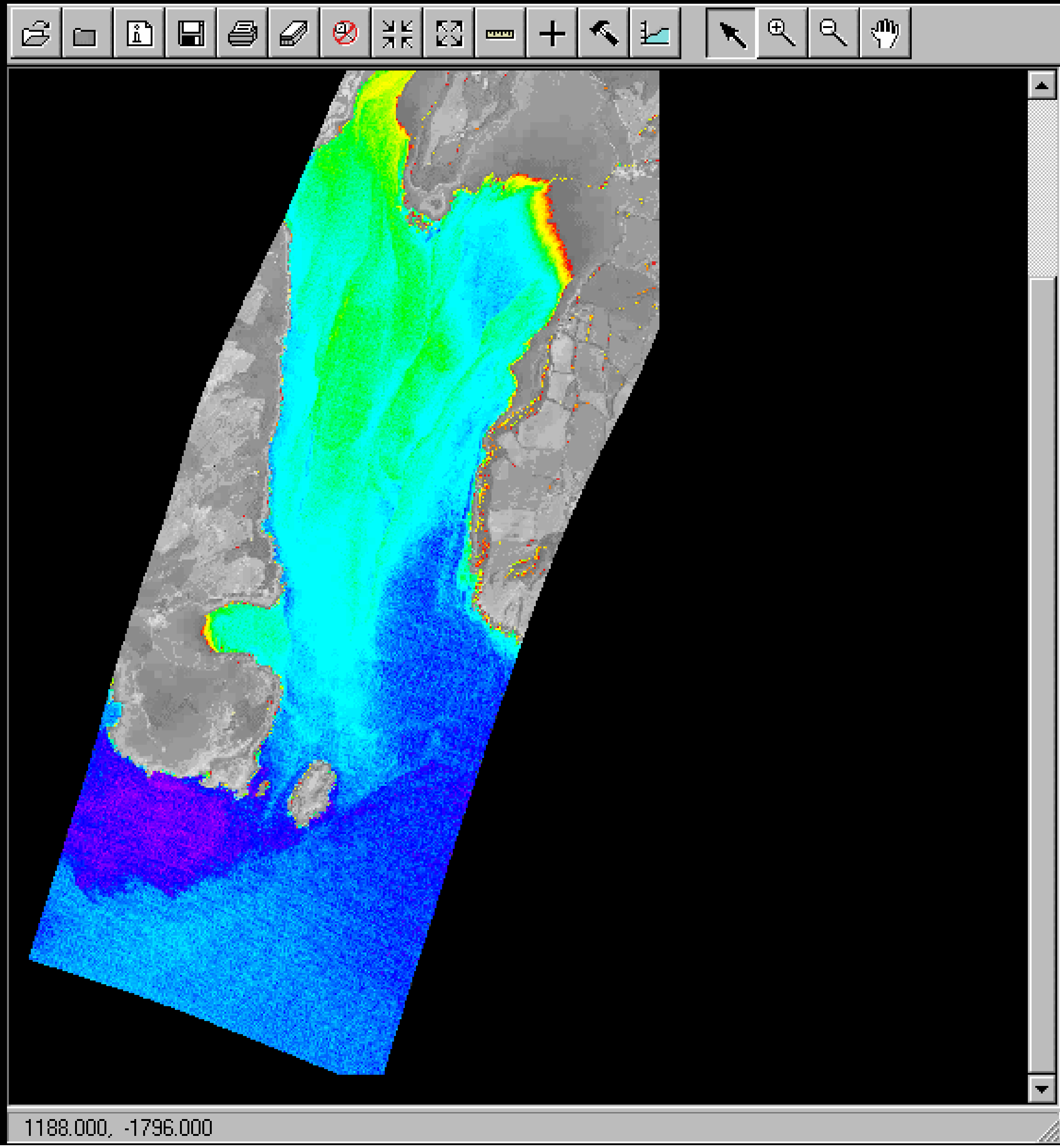
Image data processing

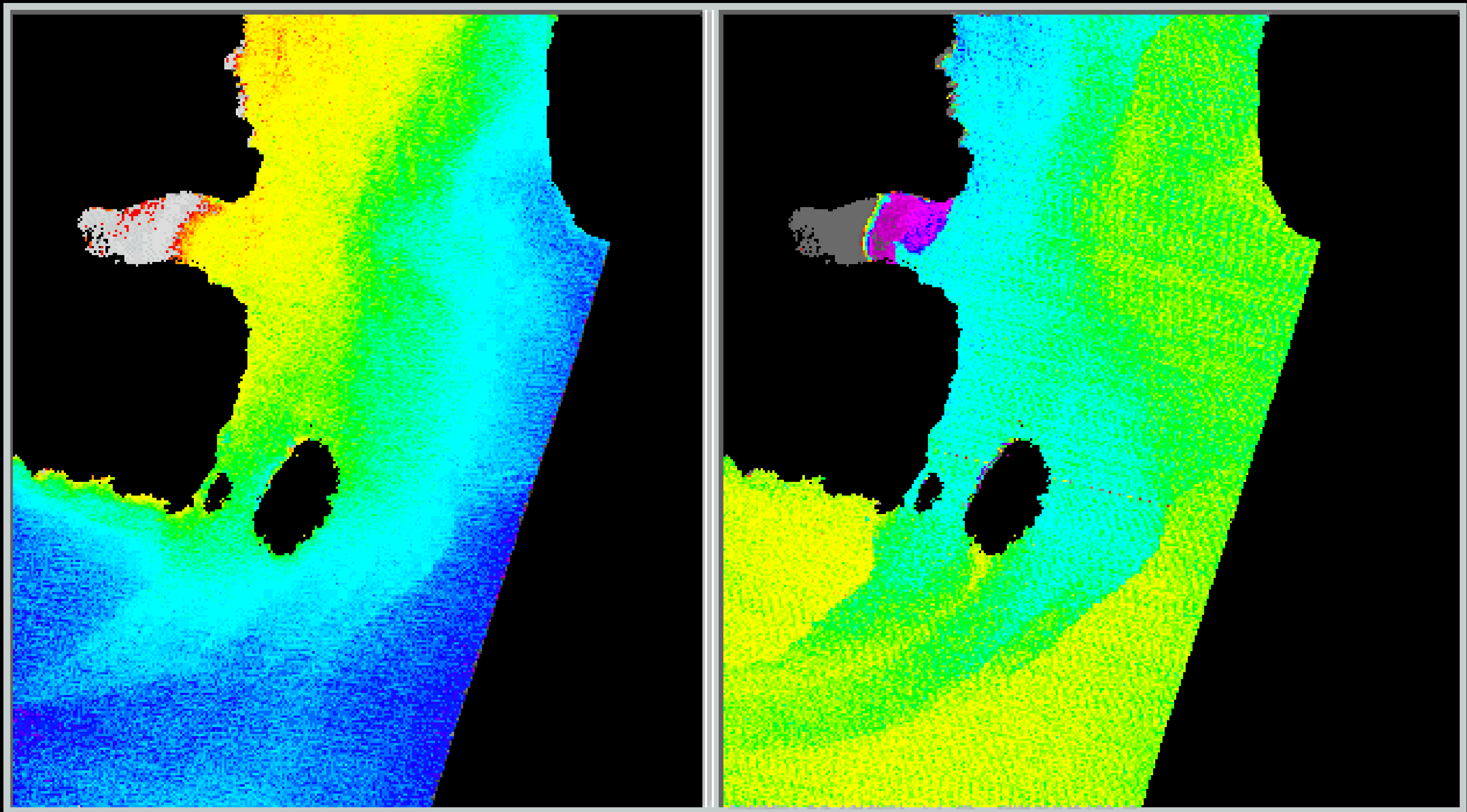
- Geometric correction
  - ➢ Supported by on-board navigation data (GPS and plane attitude)
  - ➢ Correction to 5 m resolution and image-to-image registration
- Processed to ‘indices’ of
  - ➢ Sea surface temperature (Band 11)
  - ➢ Chlorophyll-a (Band 3 : Band 2 ratio)
- Not atmospherically corrected

Thermal imagery, May

- Coherent patterns over 13 separate images
- Approximately 1½ hours in time



September imaging



Chlorophyll Thermal

Velocity calculations

- Subset to Ross Island area
- Processed image data smoothed using a 30 x 30 mean filter
- MCC used to calculate velocities
- Velocity vectors smoothed separately in both *x* and *y* directions

Maximum cross - correlation

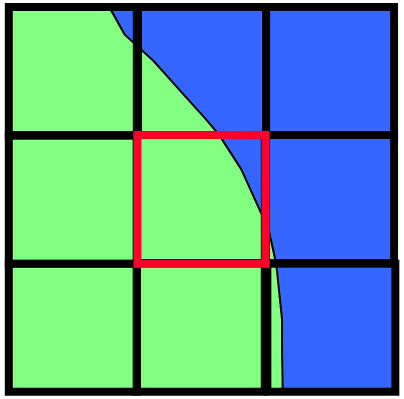


Image 1

Template window
30 x 30 pixels

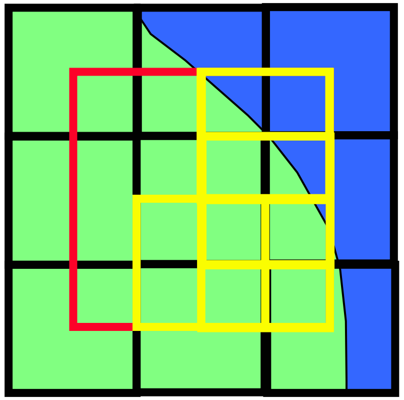
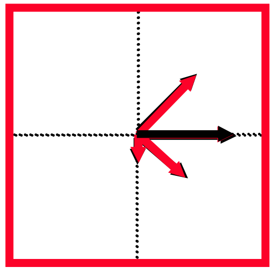


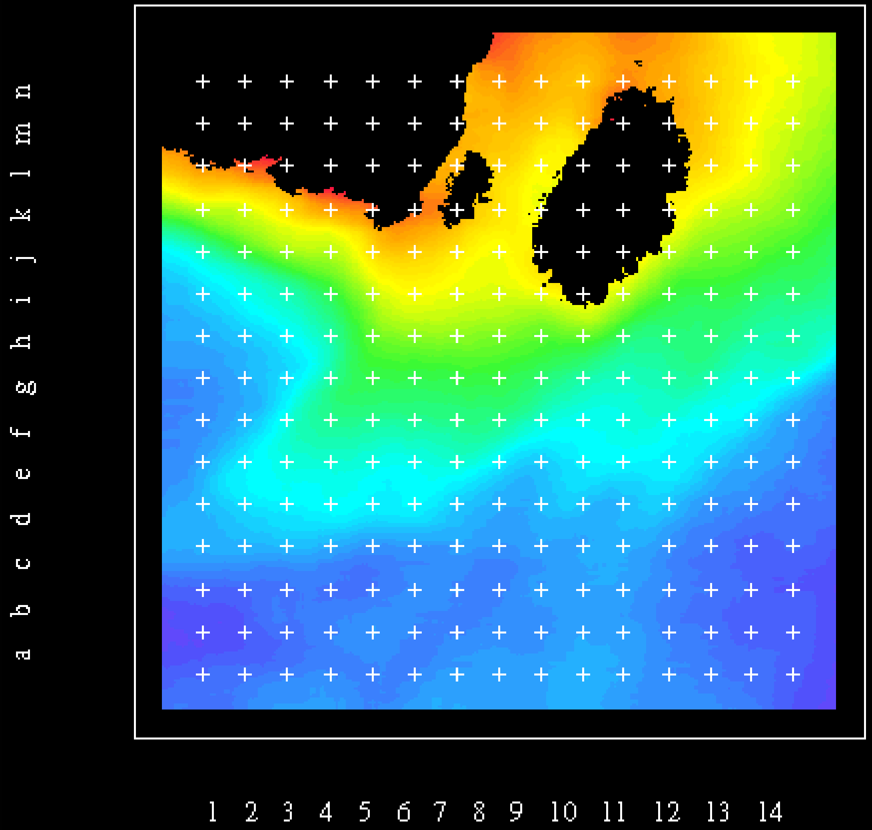
Image 2

Searching window
90 x 90 pixels



Resulting vectors

Chlorophyll index



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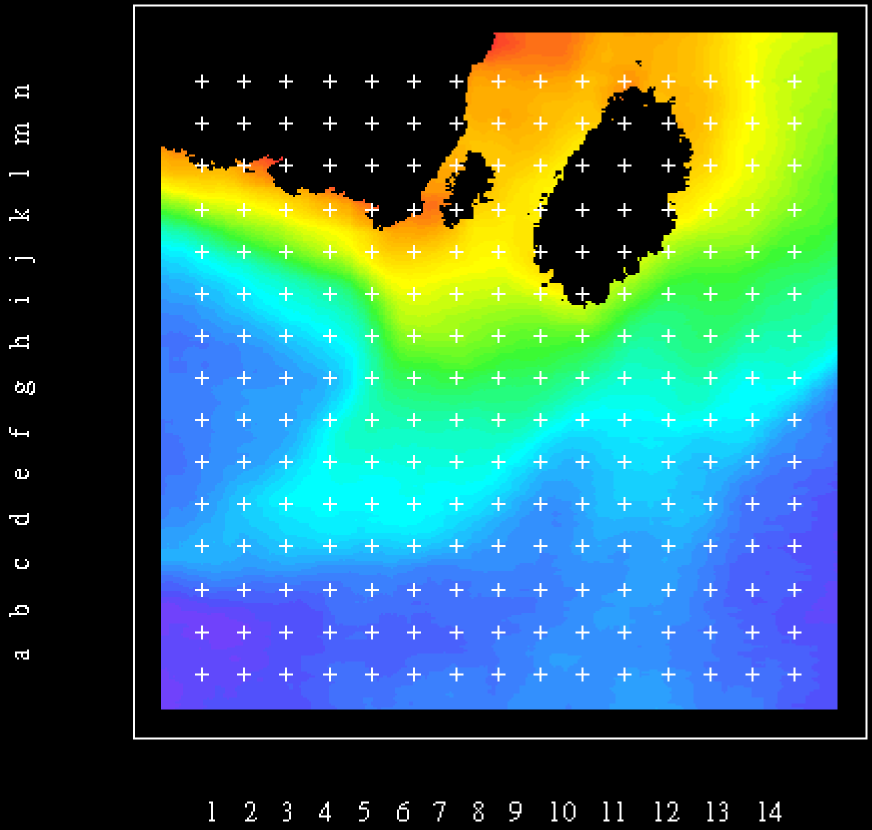

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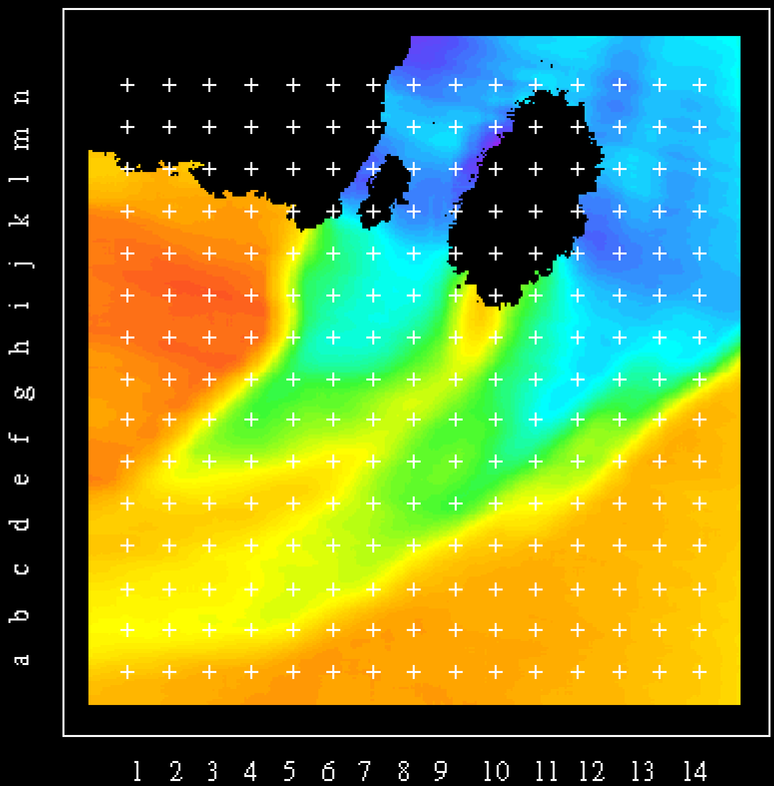
Thermal index



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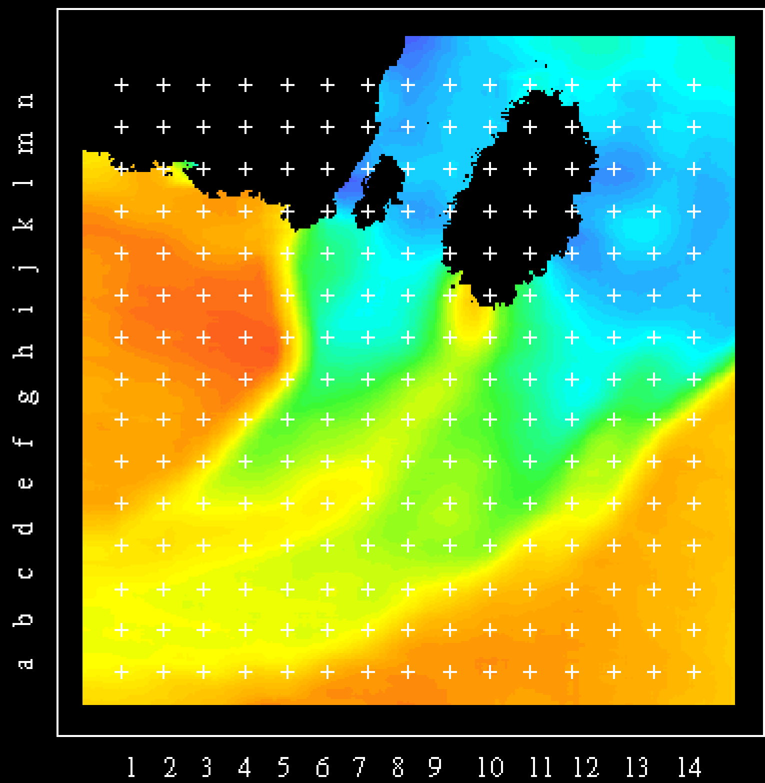

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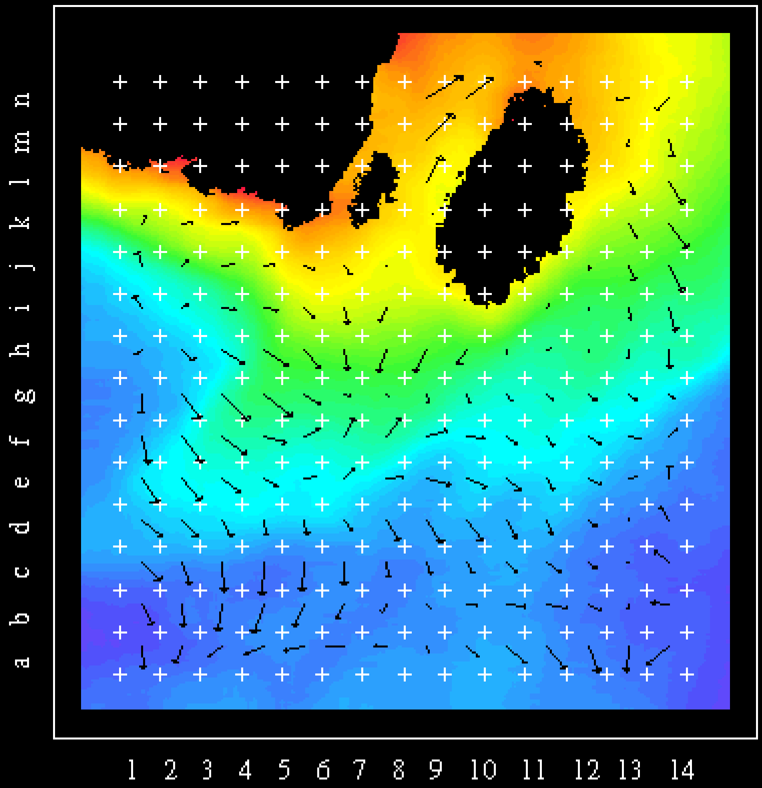
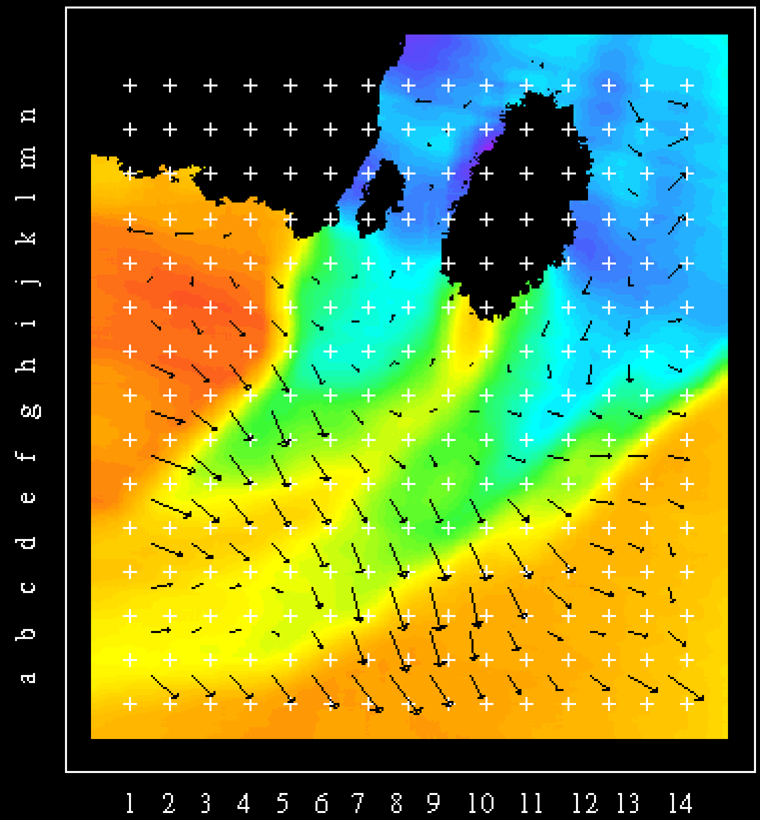
Smoothed velocity vectors

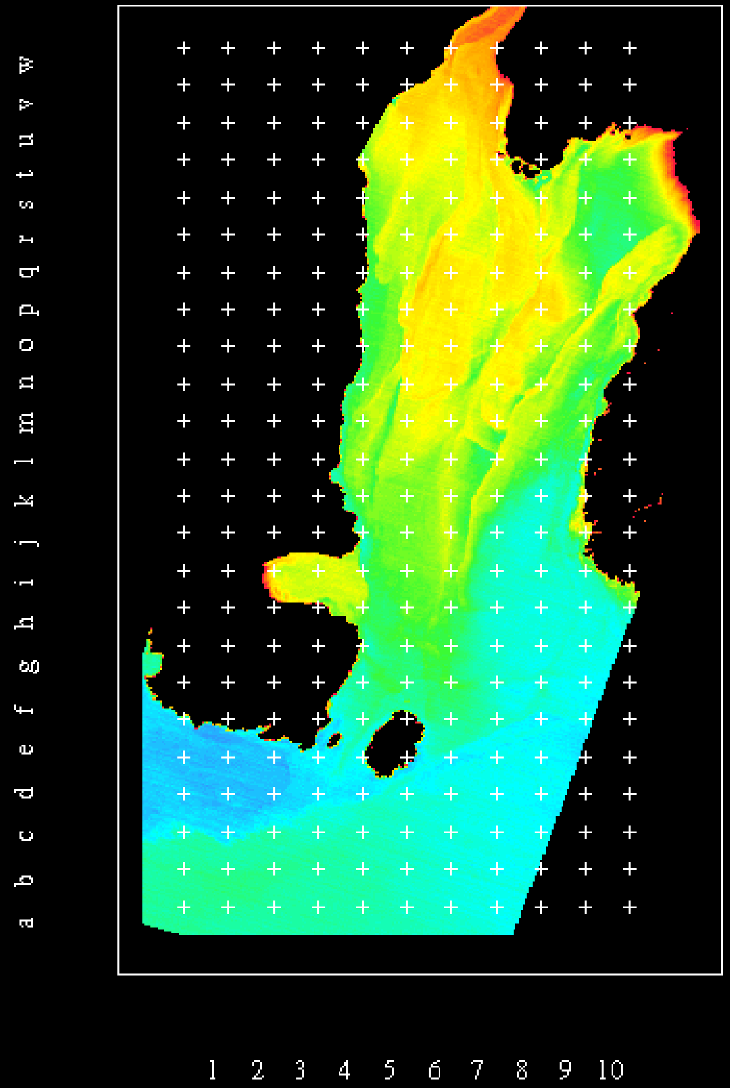


Chlorophyll image



Thermal image

At the wider scale



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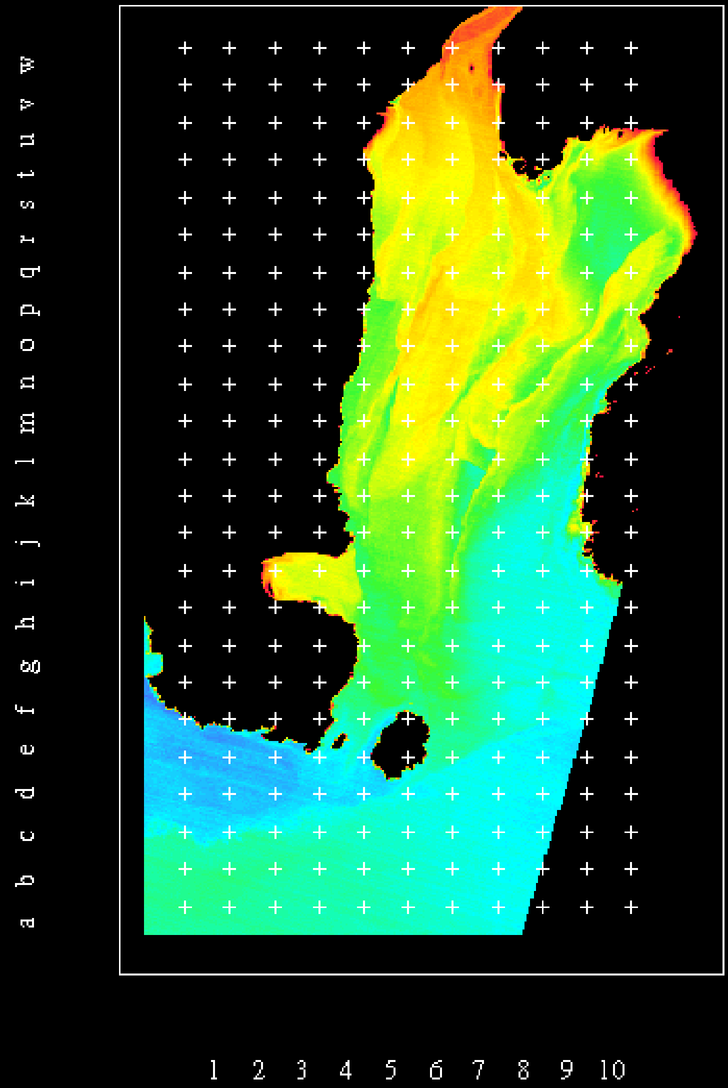

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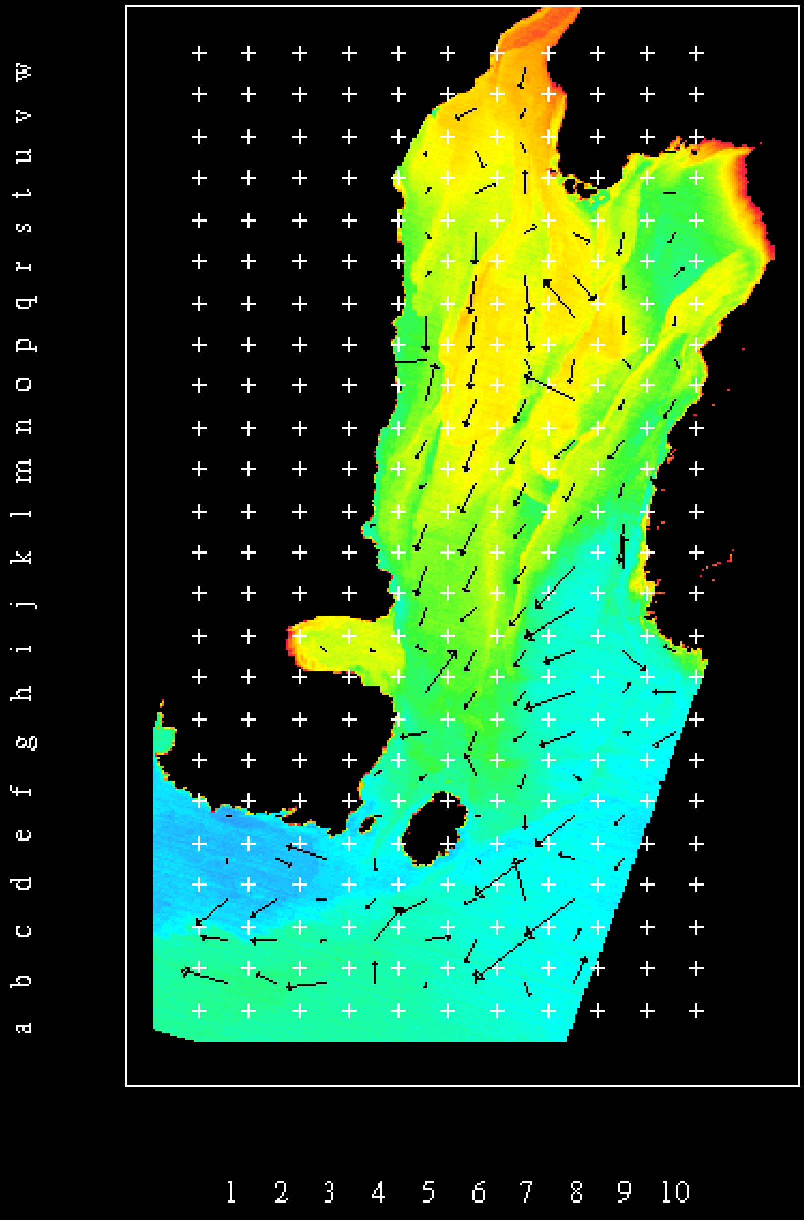
Unsmoothed vectors



Conclusions

- Approach offers unique insight into flow and residual transport processes (local scale)
- Could not otherwise be obtained at fine scale by other means (e.g. moored current meters)
- Identifies complexity at a range of scales
- Powerful technique for the improvement of CFD modelling approaches and dispersion studies in bays and estuaries
- Unique to airborne imaging - only means of meeting the temporal and spatial requirements

Conclusions #2

- Possible to analyse velocities based on water quality properties
- Different vector fields produced by:
  - Temperature images (skin surface)
  - Chlorophyll images (deeper)
- Offers indication of 3-D behaviour

Limitations, future work

- Effectiveness of MCC is reduced by
  - Homogeneity
  - Diffusion of pattern at the scale of the cell
  - Constancy of pattern
- Future work
  - Refinement of the MCC technique
  - Determination of optimal scale for analysis
  - Alternative methods (neural networks, surface annealing)