Understanding sea surface temperature measurements made by 4 different instrumental methods on a Ship of Opportunity.

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NOC
• The ship and the route
• Sensor descriptions
• Software Filter development
• Results
• Conclusions
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The ship

- P&O MV Pride of Bilbao
- Ferrybox 2002 - 2010
- Speed 20 knots
The route

- Portsmouth, UK to Bilbao, Spain
- 1000 km each way
- There and back takes 3 days
- 3 hour turnaround in port
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• Sensors
  • Hull
  • ISAR
  • CPR
  • Ferrybox
• Sensors
  • Hull
  • ISAR
  • CPR
  • Ferrybox
SBE 48 Hull sensor

- 5 metres deep
- Hull temperature
- Stable thermistor
- Every 30 seconds
SBE 48 Hull sensor

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ISAR - Infrared Sea surface temperature Autonomous Radiometer

- Bridge Top (35 metres)
- Skin temperature
- 1 minute average
- Every 3 minutes
• Sensors
  • Hull
  • ISAR
  • CPR
  • Ferrybox
RBR thermistor

- Thermistor on a towed body
- 2 minute sample
- 5 metres depth

CPR - Continuous Plankton Recorder

View of the ship’s wake
• Sensors
  • Hull
  • ISAR
  • CPR
• Ferrybox
Ferrybox flow through housing

- Intake at 5 metres
- Flow through housing temperature
- Aanderaa thermistor
- Every 15 seconds
• Results

• Ferrybox – Hull
• Results
  • Ferrybox – Hull
• Results

• Ferrybox – Hull
This gives us evidence of a time lag between hull and Ferrybox. The hull sensor responds rapidly to temperature changes. Mixing in the flow through system smoothes the Ferrybox temperature signal. So how do we directly compare the sensors that have different levels of smoothing?
Software filter development

- We apply a software filter to iteratively smooth the signal from the hull sensor.
- The degree of smoothing required is given by a maximum in the regression coefficient.
Filter results

• The software filter dramatically reduces noise generated by comparing data sets that have different levels of smoothing.

• The filtered differences closely follow a loglogistic distribution.
CPR tow data

- The filter enables comparison of data sets that have different levels of smoothing.
- The same technique is applied to the measurements made between Hull and ISAR.

All data from 2009

Hull – filtered ISAR

![Histogram for Hull - filtered ISAR data](image)
CPR tow data

- The filter enables comparison of data sets that have different levels of smoothing.
- The same technique is applied to the measurements made during the CPR tows during 2009.

All data from 2009

Hull – filtered ISAR

CPR tow data from 2009

ISAR – filtered CPR

Hull – filtered ISAR

Hull – filtered CPR
CPR tow data

- The filter enables comparison of data sets that have different levels of smoothing.
- The same technique is applied to the measurements made during the CPR tows during 2009.

All data from 2009

Hull – filtered ISAR

CPR tow data from 2009

ISAR – filtered CPR

Hull – filtered ISAR

Hull – filtered CPR
• The skew in the distributions indicate the CPR is sometimes not measuring the same water as the ISAR and Hull.

• This can occur in regions of stratification.

• The same technique also resolves diurnal heating effects observable in the ISAR data.
Conclusions

Application of the described software filter

- Enables quantification of the time lag between sensors
- Enables direct comparison of data sets that have different levels of smoothing.
- Quantifies the offsets between sensors
- Allowing the determination (discrimination) of statistical differences from other types of bias.

- And it can

- provide a numerical value that qualifies the degree of mixing occurring within a flow through system that may otherwise be difficult to determine.
• **Conclusions**
• Time lag quantification
• The filter method enables the comparison of data sets that have different levels of smoothing.
• It provides a numerical value that qualifies the degree of mixing that has occurred.
• Offsets have been quantified - determined through filter application has enabled determination(discrimination) of type A and B
• CPR –stratification
• ISAR diurnal skin effects