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

Mark Hartman

NOC

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

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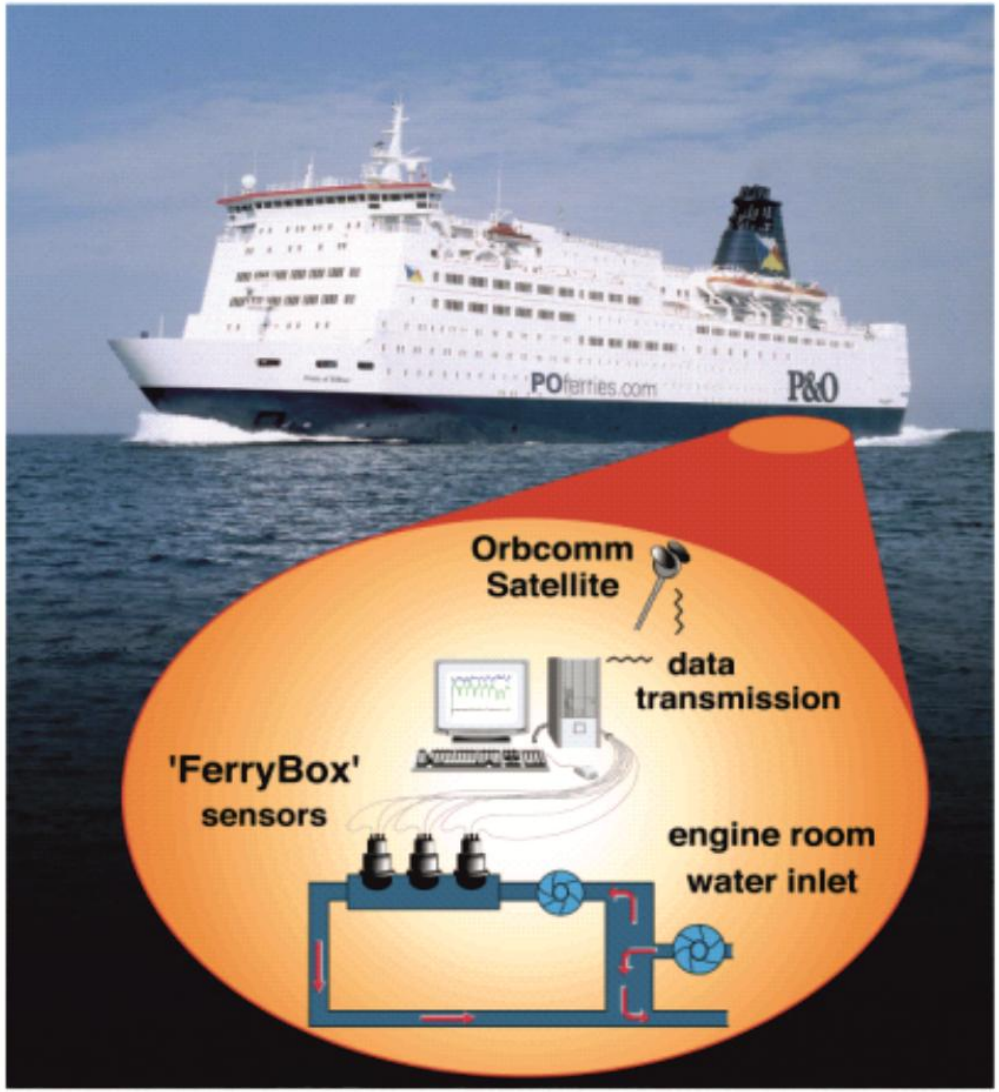
The ship

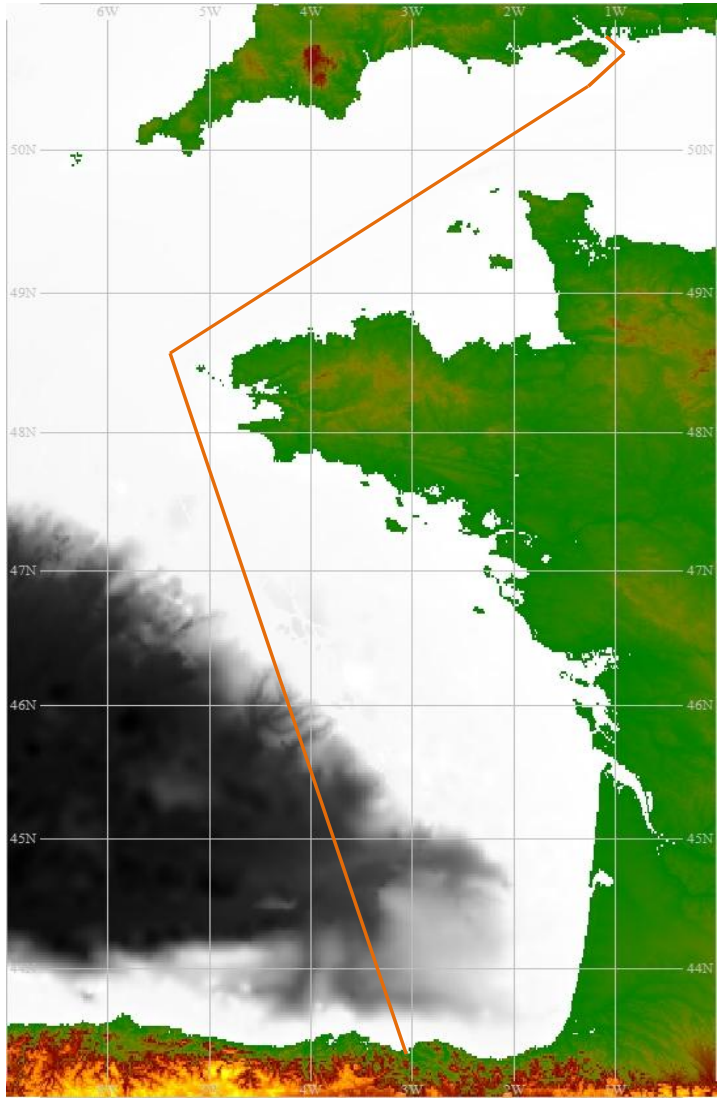


- P&O MV Pride of Bilbao
- Ferrybox 2002 - 2010
- Speed 20 knots

The route

- Portsmouth, UK to Bilbao, Spain
- 1000 km each way
- There and back takes 3 days
- 3 hour turnaround in port

Portsmouth, UK



Bilbao, ES

- The ship and the route
- Sensors
- Filter development
- Results
- Conclusions

- Sensors
    - Hull
    - ISAR
    - CPR
    - Ferrybox

- Sensors
  - Hull
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SBE 48 Hull sensor

- 5 metres deep
- Hull temperature
- Stable thermistor
- Every 30 seconds

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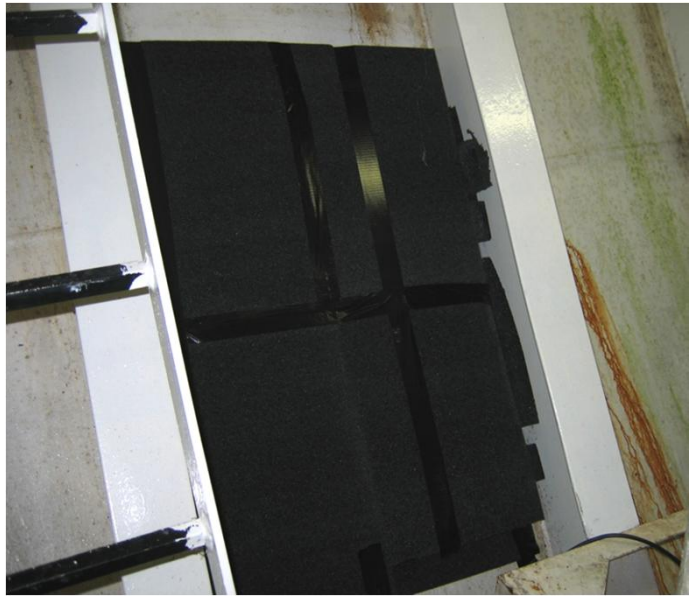


- Sensors
    - Hull
    - ISAR
    - CPR
    - Ferrybox

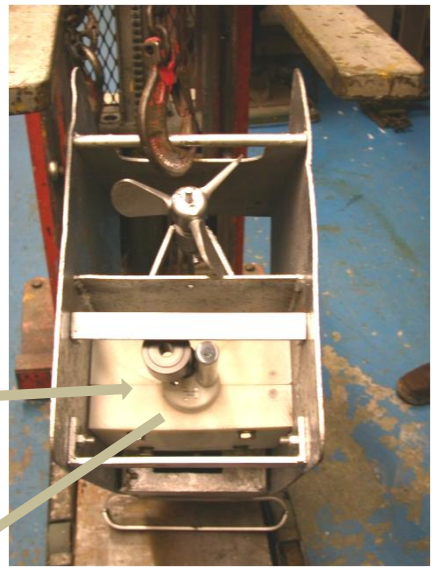
ISAR - Infrared Sea surface temperature Autonomous Radiometer

- Bridge Top (35 metres)
- Skin temperature
- 1 minute average
- Every 3 minutes

- Sensors
    - Hull
    - ISAR
    - CPR
    - Ferrybox

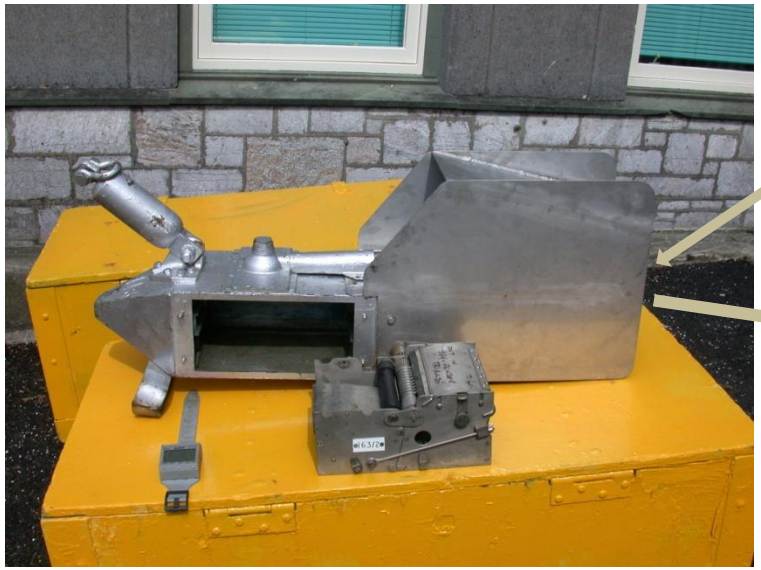
RBR thermistor

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

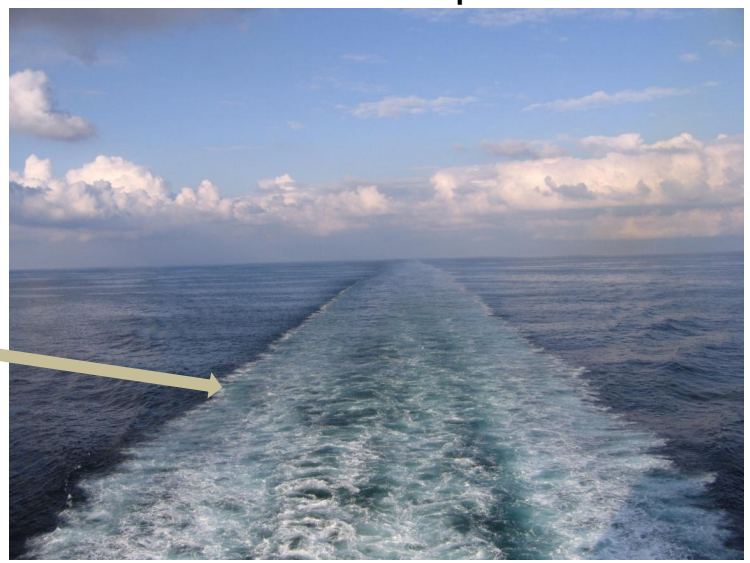


RBR thermistor

CPR - Continuous Plankton Recorder



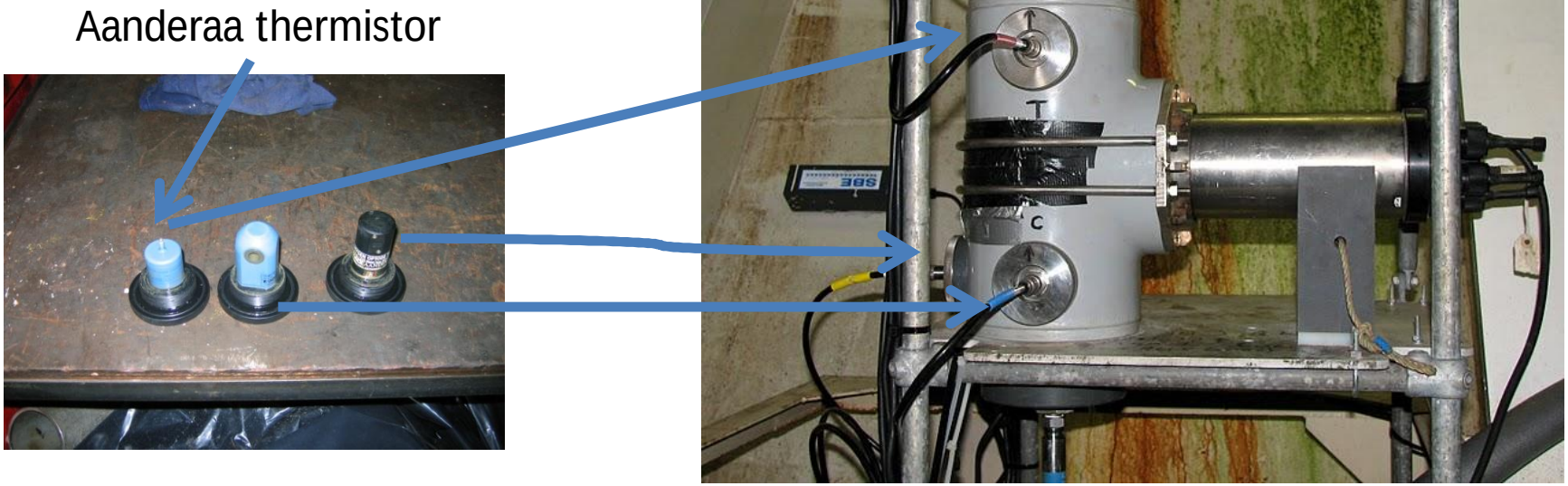
View of the ship's wake



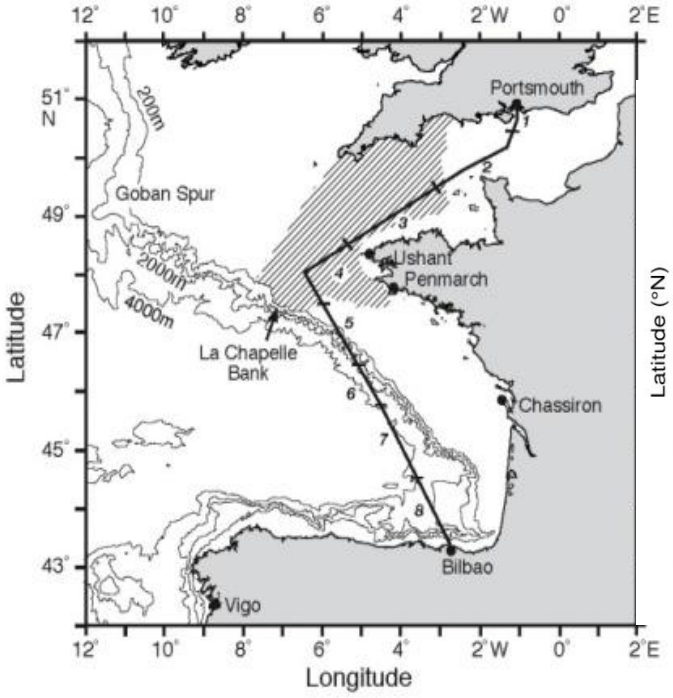
- Sensors
    - Hull
    - ISAR
    - CPR
    - Ferrybox

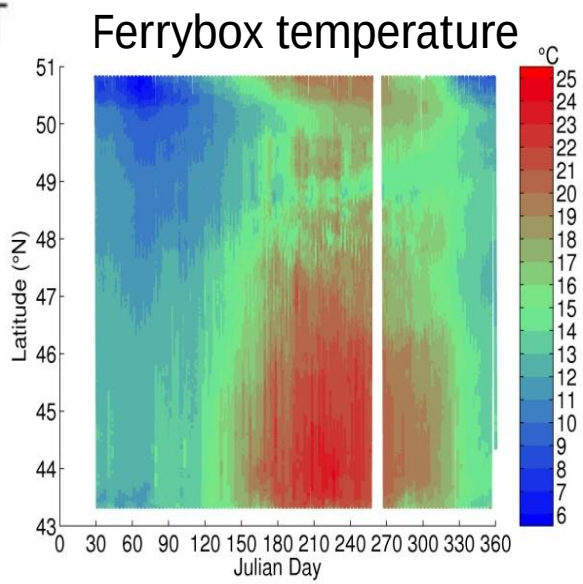
Ferrybox flow through housing

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



- Results
  - Ferrybox – Hull





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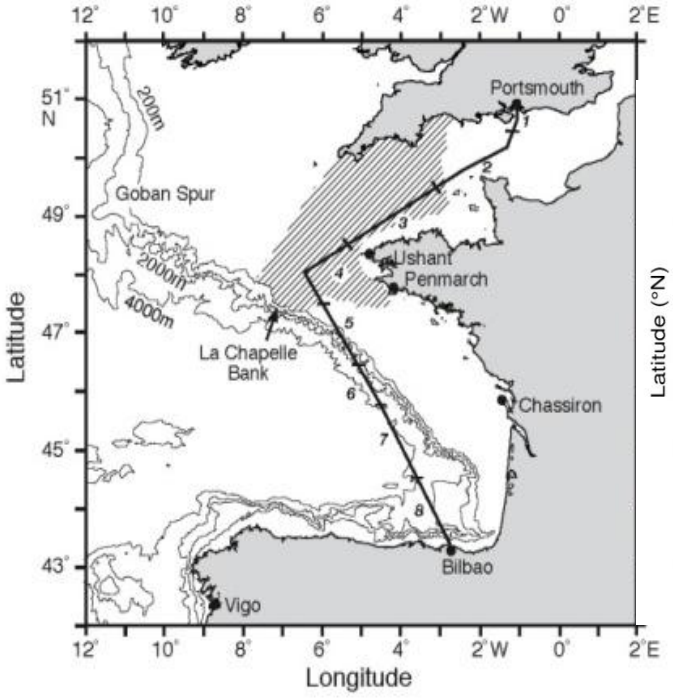

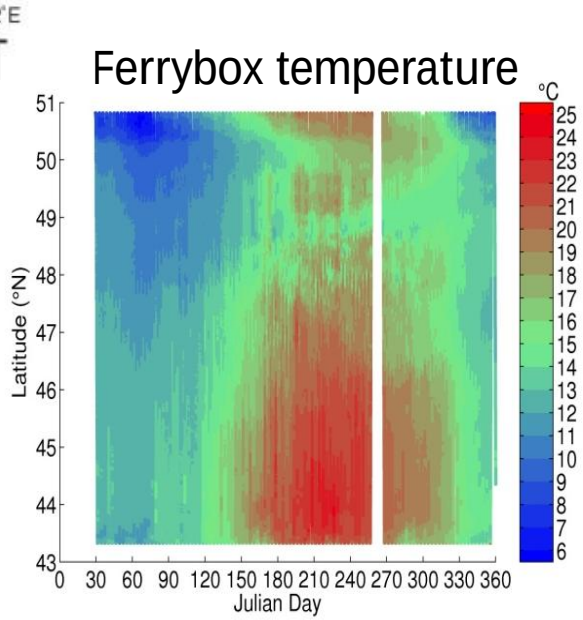

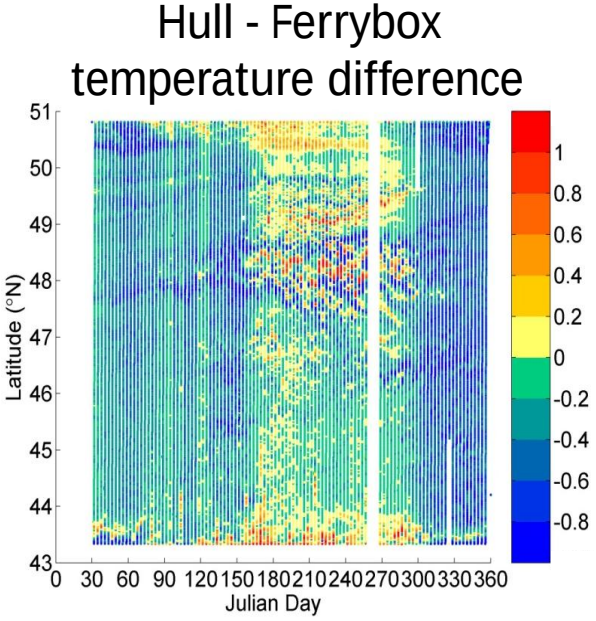

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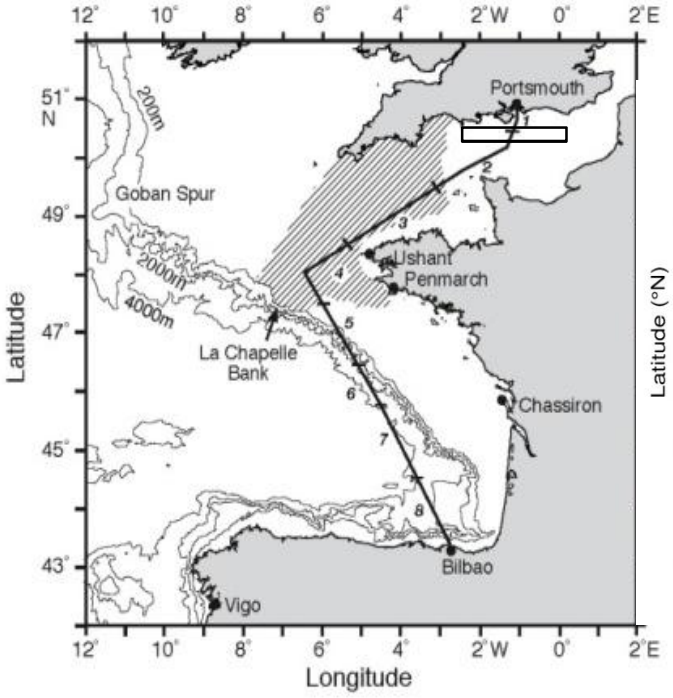
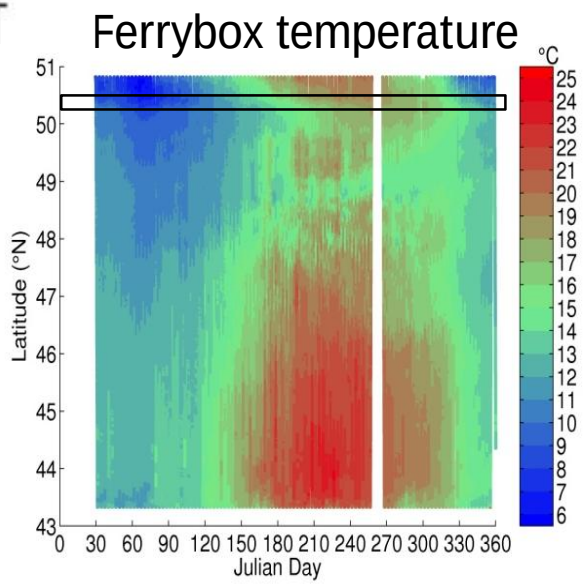
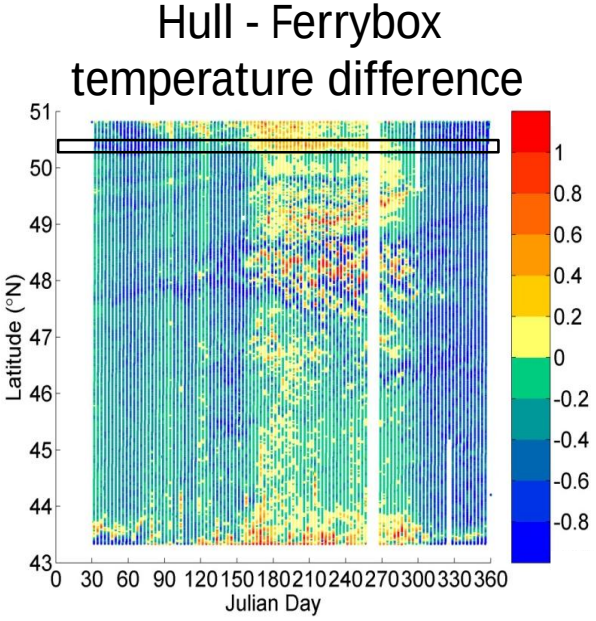
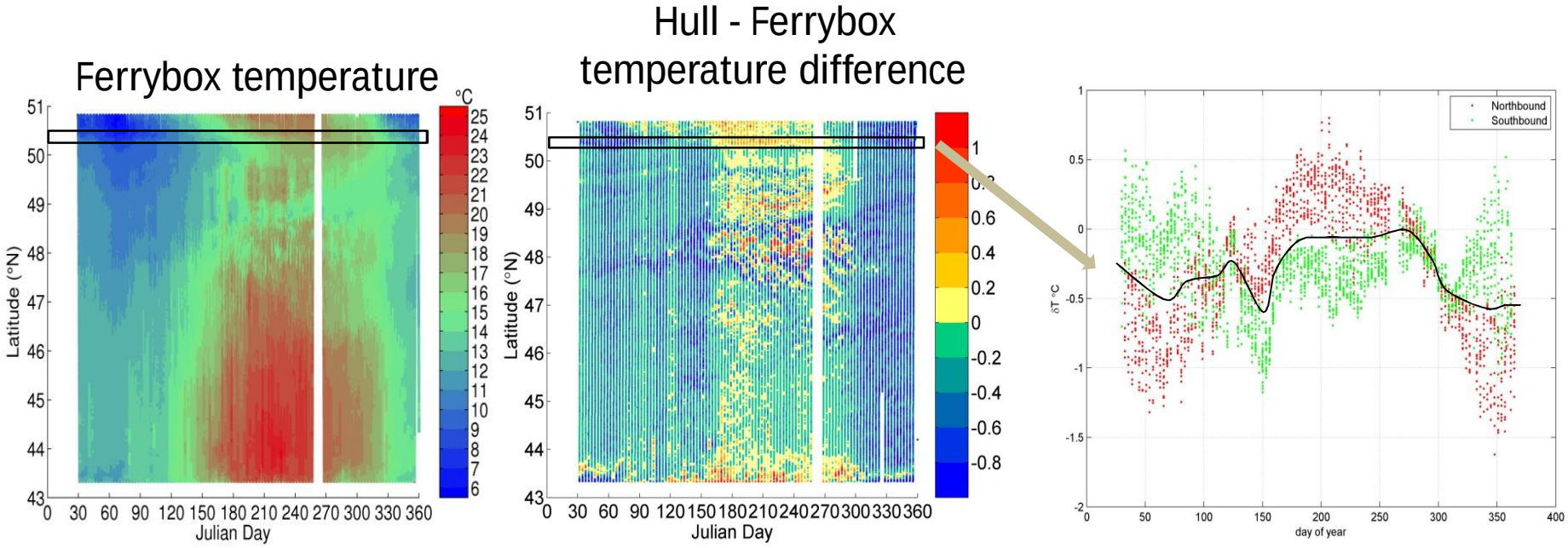






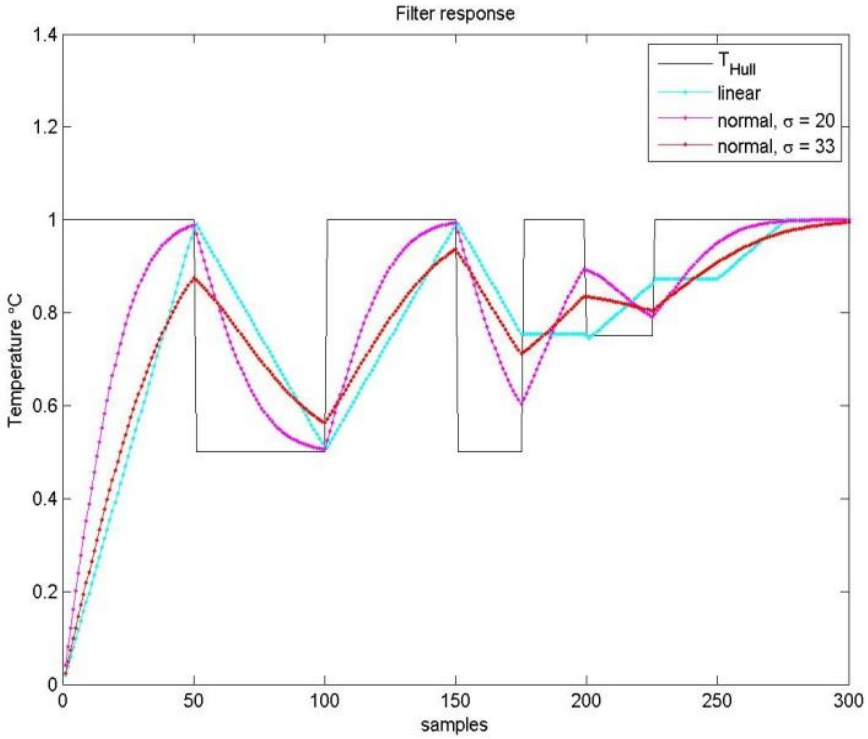
Filter development

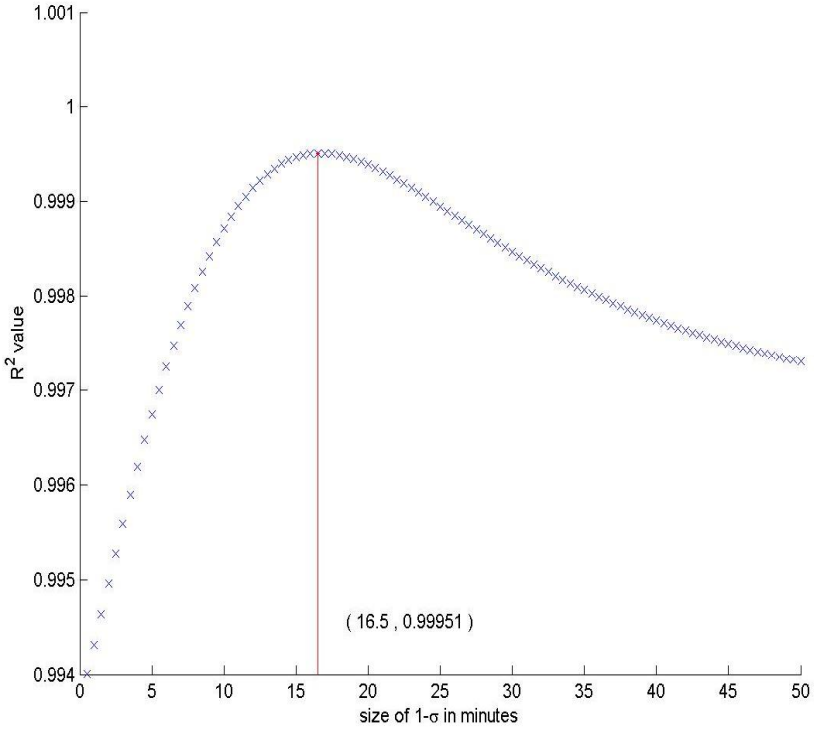


- This gives us evidence of a time lag between hull and Ferrybox.
- The hull sensor responds rapidly to temperature changes
- Mixing in the flow through system smoothes the Ferrybox temperature signal.
- So how do we directly compare the sensors that have different levels of smoothing?

Software filter development

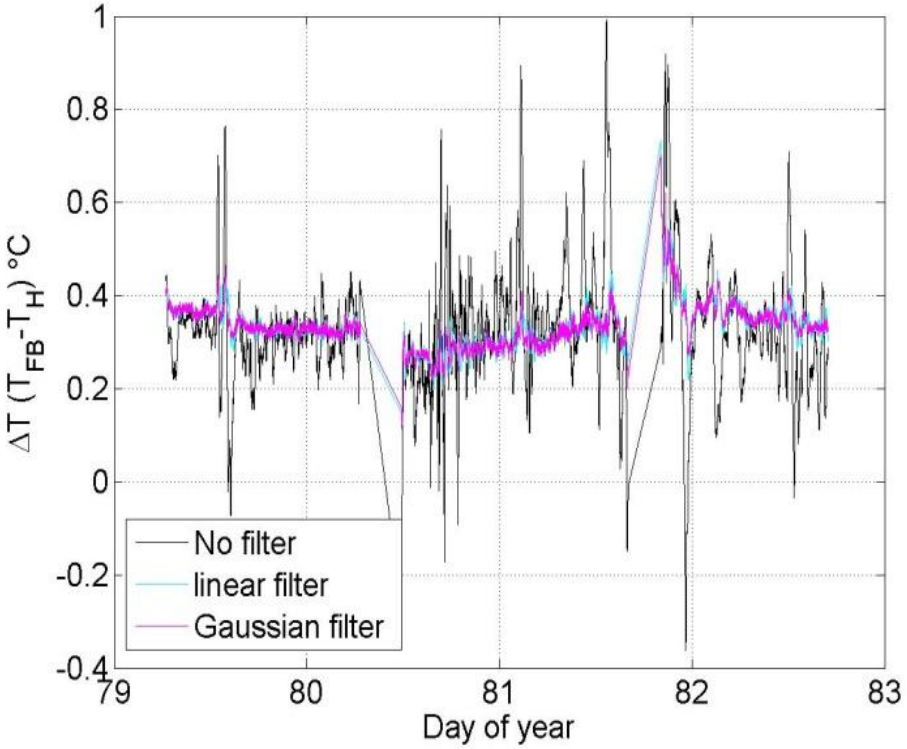
- We apply a software filter to iteratively smooth the signal from the hull sensor.
- The degree of smoothing required is given by a maximum in the regression coefficient.

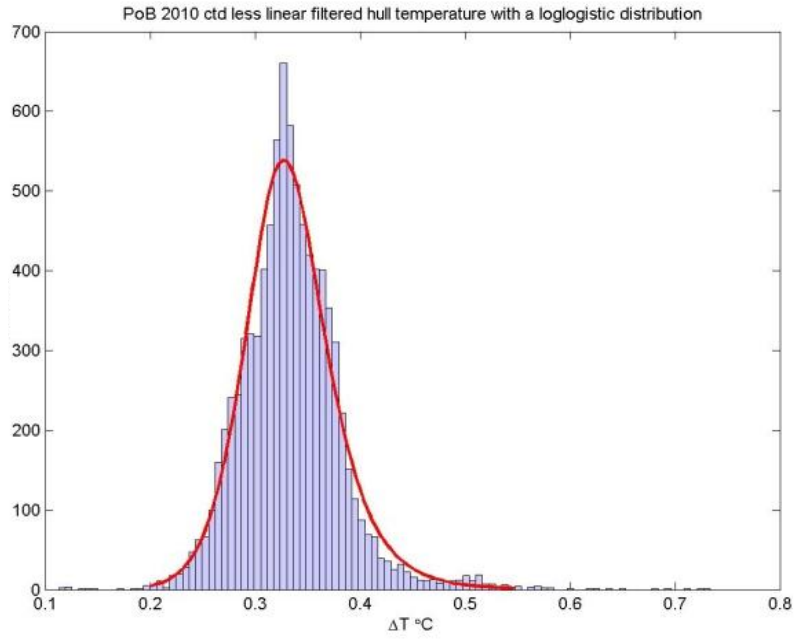




Filter results

- 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

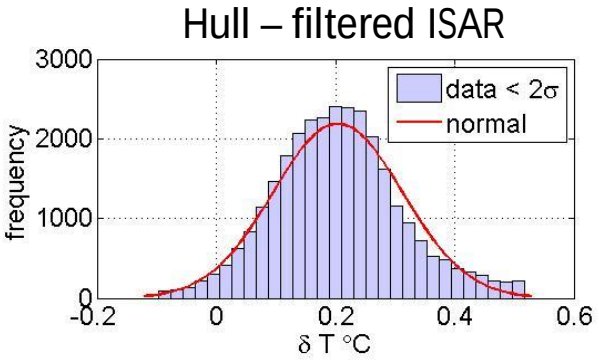




CPR tow data

- 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



CPR tow data

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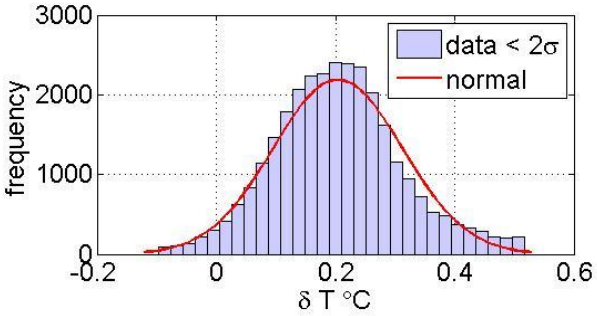
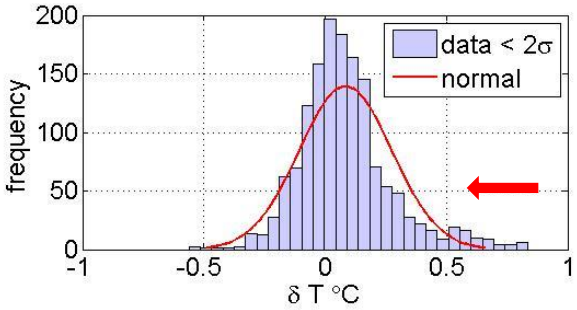
All data from 2009

Hull – filtered ISAR

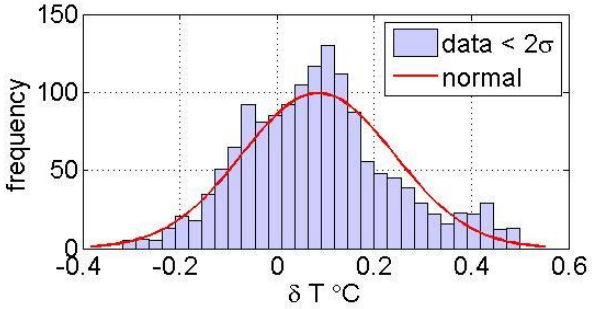


CPR tow data from 2009

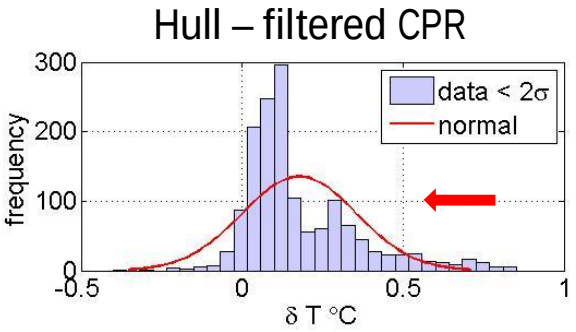
ISAR – filtered CPR



Hull – filtered ISAR



Hull – filtered CPR



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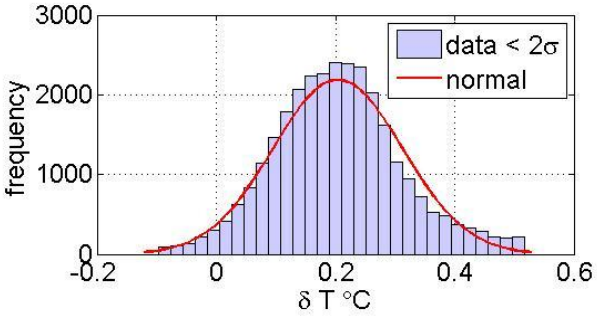

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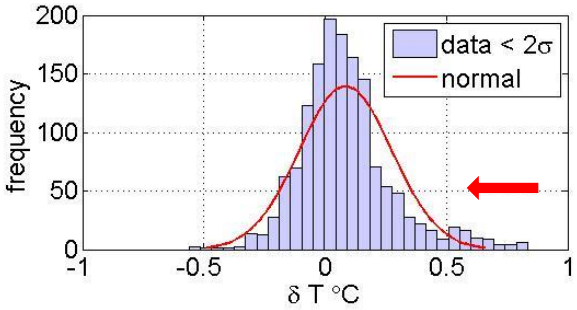
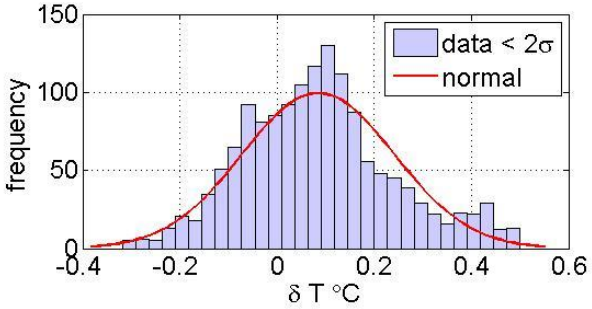
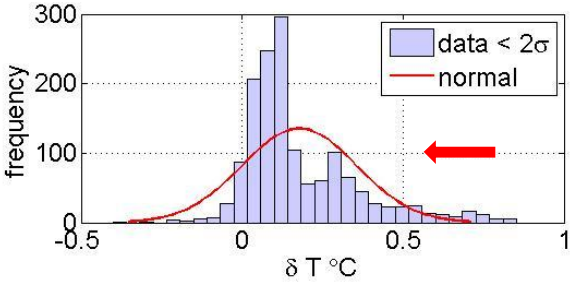


Hull – filtered ISAR



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