



shipborne radiometers for sea surface temperature

### **Experiences : ISAR - UoS**

Werenfrid Wimmer

Raymond Holmes, Ian Robinson, Craig Donlon, Gary Fisher, Kelvin Aylett, Ray Collins, ...











### **Overview**

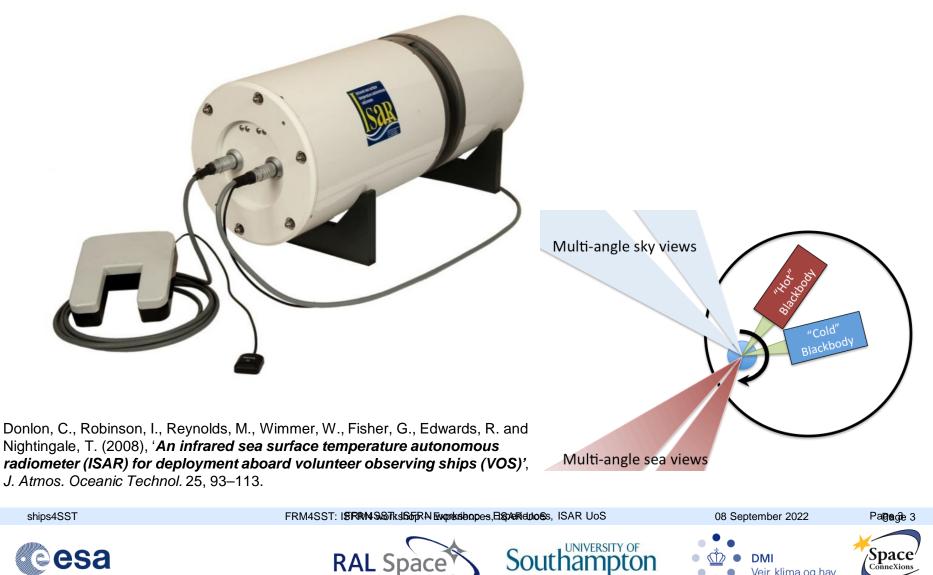
- ISAR
- Bay of Biscay and English Channel deployments
- Other deployments and projects
- Summary



ships4SST

#### **ISAR**

Infrared Sea surface temperature Autonomous Radiometer



Vejr, klima og hav

### **ISAR installed on Pride of Bilbao**

**2004 - 2010** 



- Ancillary instrumentation;
  - Anemometer
  - Short- /Long wave Radiation
  - Hull temperature (5m)
  - Air temperature, Humidity
  - FerryBox, CPR

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FRM4SST: ISRRM Substrate Burgrade appes, Esperie dio es, ISAR UoS









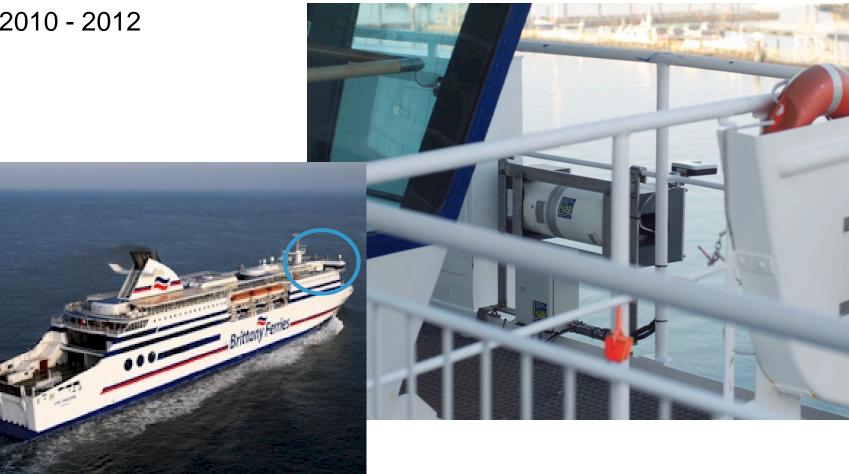
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### **ISAR installed on Cap Finistere**

2010 - 2012



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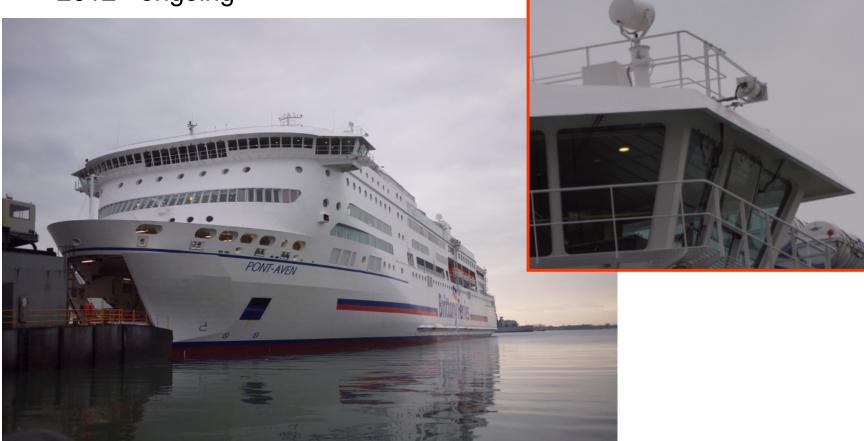






### **ISAR installed on Cap Finistere**

2012 - ongoing



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FRM4SST: ISRRM4SASTkdSoftRN Exoprexise opes, Elsperieduloes, ISAR UoS

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- Bay of Biscay and English Channel
  - 74 deployments
  - ~ 5000 days at sea
  - ~ 1 million SST measurements
  - ~ 200 SST /day
  - 12 failures:
    - 6 electronics issues,
      - 3 related to new electronics trails, 1 thermistors

FRM4SST: ISFRM4SASTkdSAFR46

**RAL** Sp

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Feb

- 4 shutter failures
- 2 configuration issues

2004			SA	R-002	SAR-002		S	AR-003		SA D4	R-002	
	Jan PoB refit		Mar	Apr	Мау	Jun	jul	Aug	Sep	Oct	Nov	Dec
2005		ISAR-003	SAF D6	R-002			ISAR-003 D7		S	AR-002		SAR-003
	Jan PoB refi	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006		IS	AR-002		BAR-	003		SAR-0	02		ISAR-00	)3
	Jan PoB refit	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	POB rein	B14-0	02		SAR-0	003 ISAR	-002	SAR-0	03			SAR-003 D18
	Jan PoB ref	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	_		AR-003			SAR-0	003	ISAR-0	03 D21	SAR-00	3	
	Jan	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	PoB ref	ISAR-00 D23	3	54	AR-002	52	JR-003	ISAR-002 D26	ISAR-003 D27			
	Jan PoB refit	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov PoB to CpF	Dec
2010			AR-003		ISAR-002 D29	ISAR-00	)3			iransier	ISAR-003	
	Jan	Feb CpF refit	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011		.pr rent			ар.003			ISAR-003			SAR-003 D34	ISAR-003 D35
	Jan	Feb	Mar	Apr	May	Jun	jul _	Aug	Sep	Oct	Nov	Dec
2012		CpF refit	ISAR-003				ISAR-003	ansfer CpF to	ISAF	-002 D38	PtA refit	SAR-002
	Jan	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013		SAR D40	-003		SAR-002		SAF B42	R-003				SAR-002
	Jan	Feb tA refit	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014			SAR-002 D44	ISAR-00 D45	3		SAR-00 D46	)2		5AR-003	ISAR-002	D48
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	PtA refit	\R-003		BA	R-002	ł	SAR-003		SAR-002	2	ISAR-0	03
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	PtA refit			S€2	R-002			SAR-003	SAR-002			ISAR-003
	Jan	Feb	Mar	Apr	Мау	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017				SAR-0	02		ISA	R-003	SAR-002			SAR-003
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018			IS D	AR-002			ISAR-003		ISAR-002 D64		PtA ref	ISAR-003
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019		ISAR-002 D66			2		ISAR-003 D67		ISAR-002 D68			
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	PtA refit			COVID-	19 layoff		IS/	AR-002			COVID-19	layoff
	Jan	Feb	Mar	Apr	Мау	Jun	jul	Aug	Sep	Oct	Nov	Dec
2021	COVID-19	) layoff					ISAR-003		15	AR-002		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct Oct	Nov	Dec
2022	PtA refit			ISAR-003		SAR-0	007	ISAR-0	003			
	lan	Feb	Mar	Anr	May	lun	, Iul	Aug	Sen	Oct	Nov	Dec

Aug

Sep

Oct

Nov

Dec

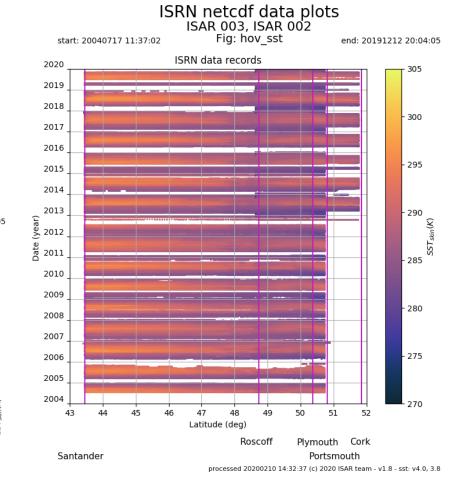


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 Bay of Biscay and English Channel data

ships4SST

ISRN netcdf data plots ISAR 003, ISAR 002 Fig: track\_sst start: 20040717 11:37:02 end: 20191212 20:04:05 305 ISRN ship track 52 300 51 50 295 49 48 290 skin(K) Latitude 42 SSTs 285 46 45 280 44 43 275 42 -10 <u>\_</u>9 -6 -5 -3 -2  $^{-1}$ Longitude 270

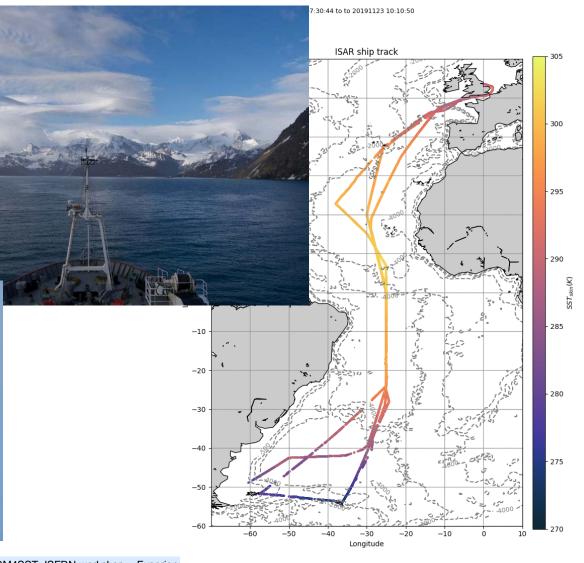


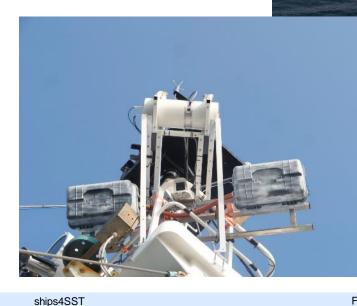
processed 20200210 14:32:49 (c) 2020 ISAR team - v1.8 - sst: v4.0, 3.8



#### AMT

- 4 cruises
  - 2016, 2017, 2018, 2019
- 166 days
- ~ 40 000 SST
- ~ 250 SST /day
- ISAR side by side comparison





FRM4SST: ISFRN workshop - Experience





processed 20200915 (c) 2020 ISAR team - v1.1

DMI

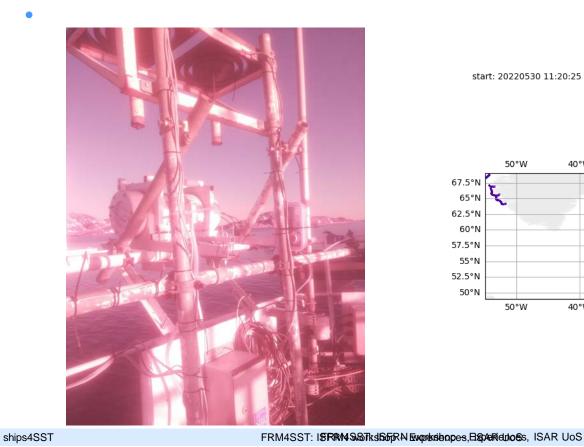
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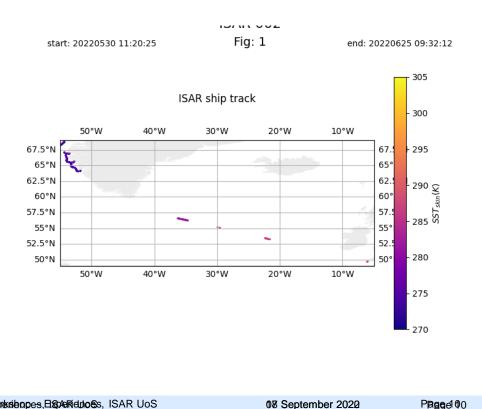
Space

ConneXion

AMT like

- DY151
- Instruments only, some issues due to COVID protocols and instrument access









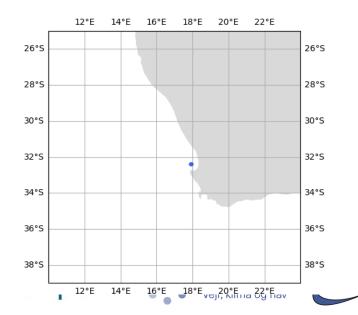
Space

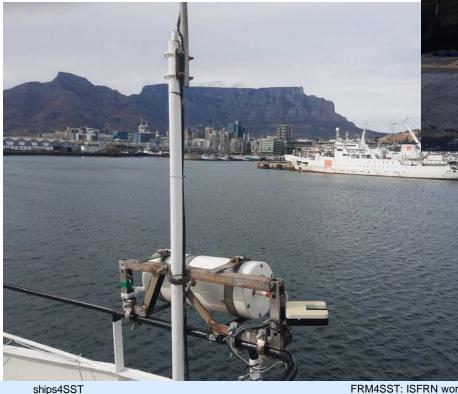
ConneXion



- S/A Algoa / BENFLUX
  - December 2021 protocols and instrument access







FRM4SST: ISFRN worksl

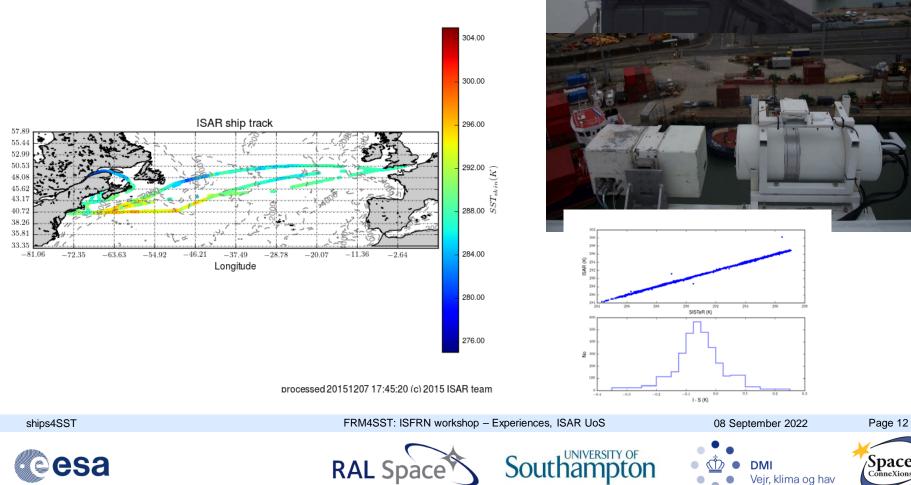




#### QM2

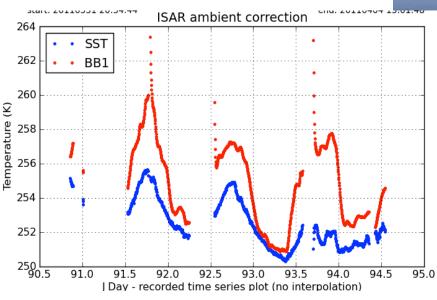
- ISAR SISTeR side by side inter-comparison
  - 2015

ISAR time: 20150920 11:35:03 to to 20151105 09:11:31



- FRM4STS ICE
  - ISAR inter-comparison
  - 2016, (2011)

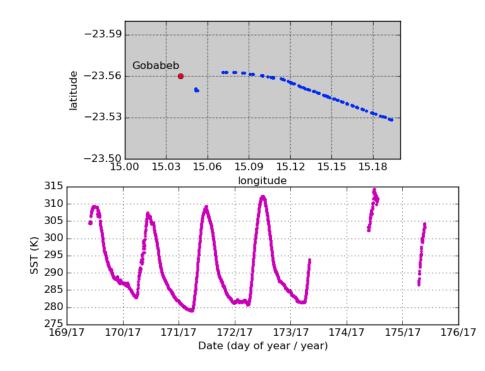






esa

- FRM4STS Land
  - 2017







esa

FRM4SST: ISFRN workshop – Experiences, ISAR UoS

**RAL** Space

Southampton

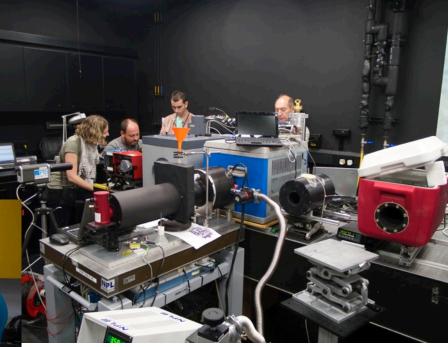


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- FRM4STS NPL
  - 2016





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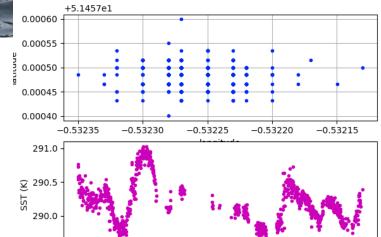


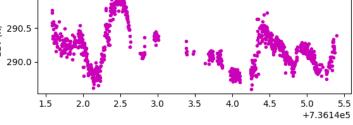


- FRM4STS SST
  - 2016









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Spac

ConneXion

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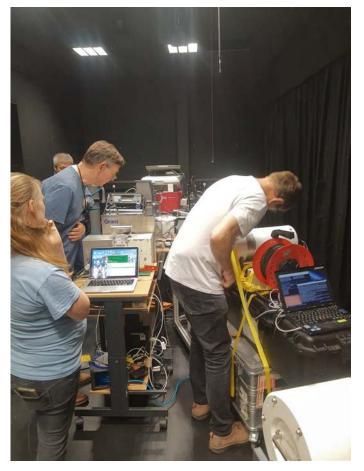
FRM4SST: ISFRN workshop - Experiences, ISAR UoS

**RAL** Space

Southampton



- Intercomparison NPL
  - 2022





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FRM4SST: ISFRN workshop - Experiences, ISAR UoS

08 September 2022













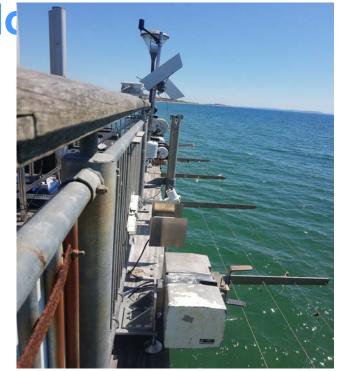
# **ISAR deplo**

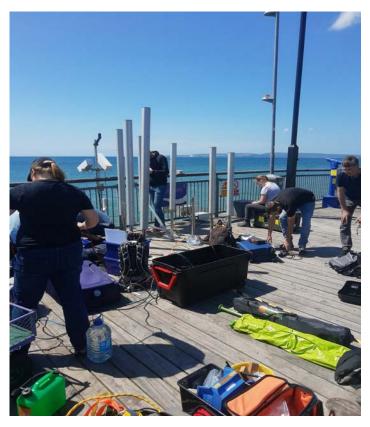
- Intercomparison
  - SST
  - 2022

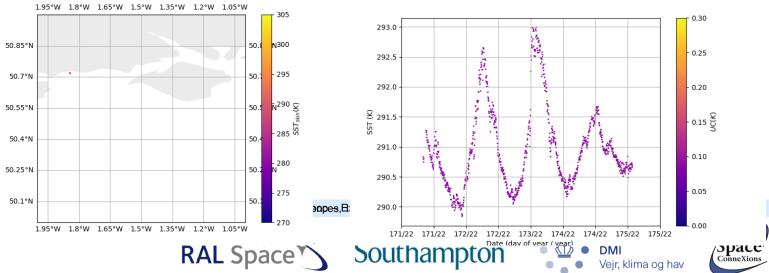
ships4SST

esa

Boscombe







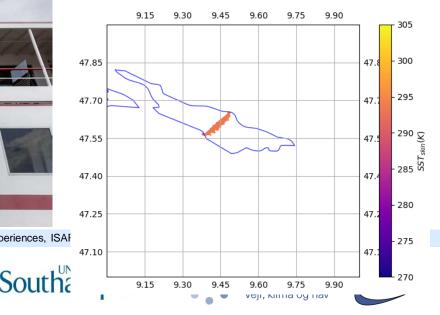
- EUMETSAT LWST
  - Lake Constance
  - ISAR KT15 inter-comparison
  - 01.09.2020-23.09.2020





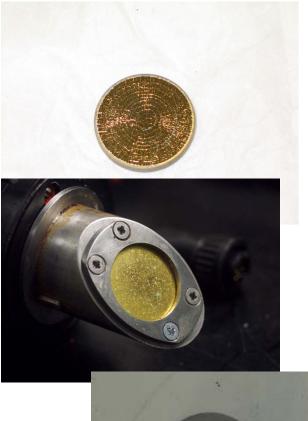
**RAL** Space







#### **ISAR experience**





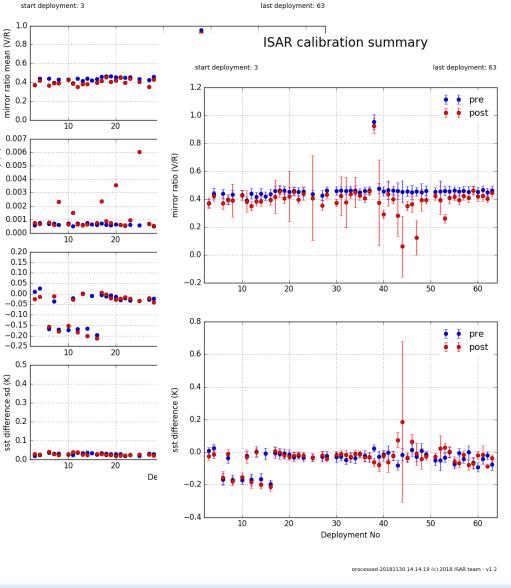
#### ISAR calibration summary

ratio sd (V/R)

or

mir

sst difference mean (K)





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Southampton

#### ISAR



#### Infrared S Temperat Radiomet

ISAR Procedures Manual v1.02

W. Wimmer Ocean and Earth Science National Oceanography Centre Southampton University of Southampton Waterfront Campus European Way, Southampton, SO14 3ZH, U.K.

Reference: Procedures\_manual\_v1.02 Issue: 01 Date of issue: ovember 2013 Document type Procedure Manua

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#### ISAR User Manual v2.05

W. Wimmer Ocean and Earth Science National Oceanography Centre Southampton University of Southampton Waterfront Campus European Way, Southampton, SO14 3ZH, U.K.

Reference: ISAR-User-Manual-v2 05 2.05 March 2018 Date of issue User Manua

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# © Werenfrid Wimmer, Craig Donlon,

This is the version history for main ISAR PP processor, which is used by a number of tools in the ISAR

processor version history

ISAR sea surface temperature post

PP software suite.

#### 1. CHANGELOG

#### Version v4.0- 14.11.2018

#### Bug fixes to v3.9:

 CalcEmissvityUncertainty, angle\_roll = self.c\_ufMissing, self. was missing. o ShutterState added fix for ISAR5D shutter disabled codes 10 and 11).

ISAR post processing manual

- Astral location() doited the processor. Nation speed 17.137-012 ments in the uncertainty estimation routines.
- Deployment.cfg changes:
- Config file ('deployment.cfg') is now command line configurable New function SetDepInfoDefault for default (UOS) values in case they are not defined indeployment ofgal 4.0 Page 1 of 62
  - bSeaSkvViewOverRide has new value 2, which allows for angels instead of array positions for the sea and sky view angles. Added new function GetSkySeaViewIndex() to convert angles to index in the processing.
  - No deployment.cfg reader in the write\_isar\_sst\_v4.0.py anymore, all configuration values are read inti isar\_v40.py.
  - New variables for three skyviews: SkyViewUpper, SkyViewLower and SeaWaterEmissivity. These override ISAR header information.
  - Actual Skyview and Seaview angle added to the L2R file.
  - . write\_isar\_sst\_v4.0.py can process multiple sky angles in one step. To achieve this new variables in deployment.cfg, see above.

#### Version v3.9- 20.08.2018

- Bug fixes to v3.8:
  - o Fix to to BB thermistor differences for Engineering plots so plotting still works by not resetting sample[0,1] number to zero in calcSSTskin\_from\_i5.
- Changed view\_angles and target\_sample field size from 10 to 20 in isar\_struct\_ua for isaros v2.6.2 20 scan samples update.

#### Version v3.8 - 30.04.2018

- Bug fixes to v3.7:
  - solar azimuth isar was -360 to 400 degrees is now -180 to +180 relative to ISAR position.

```
ships4SST
```





Date: 05.08.2004 No - IS-IP-001



failed on the 15.06.2004, which left the shutter jammed in



were carried Figure 1: Image of the jammed shu brations in the acilities at the Pride Bilbao as found 15.06.2004 aphic Centre 15.06.2004. If the instrument behaviour under deployment temperature

ach was done for the ambient temperatures of 10, 15 and

2 was jammed in an half open position (see figure 1). atory showed that under certain conditions the shutter ys got jammed in the position shown in figure 1. This be overcome with helping to push the shutter along from thorough investigation of the problem the instrument had to as the next step.

d that the sprocket which drives the drive belt and ad some of broken off teeth (see figure 2). Furthermore it had worn down guite substantially because of the wear ket. As a result of the wear and the broken off teeth the iluminium dust and some bigger parts form the teeth (see h was used on the sprocket drive belt interlink collected all drive belt and consequently increased the wear on the

a certain extent able to drive through these particles, ight tolerances on the shutter door the amount of torque st by the motor indefinitely. This eventually led to the urrent limiting electronics on the shutter motor limited the way that the shutter motor could not provide the torque riction (Note that the shutter motor suffered no harm).

1 of 2







FRM4SST: ISFRN workshop – Experiences, ISAR UoS





## **ISAR experience**

- 16 years of near continuous operations
  - English Channel and Bay of Biscay
- Lots of high quality data
- One of the longest SST skin data records
  - More than 1000000 SST measurements
- Autonomous instrument, works in most environments
  - However needs careful maintenance
- Expansion to other areas AMT
- Protocols for installation
  - Instrumentation
  - Ship owners
- Failures
  - Design changes (shutter, mirror, electronics)
  - Improved maintenance and pre-deployment checks



# **ISAR customers**

- University of Miami
- Ocean University China
- JAXA
- Royal Navy
- Danish Metrological Institute
- WHOI
- CSIRO
- Seoul National University
- Vaisala (Australian Antarctic Division)
- National Ocean Technology Center of China
- MetNo

