Assessing the Impact of Aerosol on the Accuracy of IASI SST

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(2) EUMETSAT, EUMETSAT Allee 1, 64295 Darmstadt, Germany
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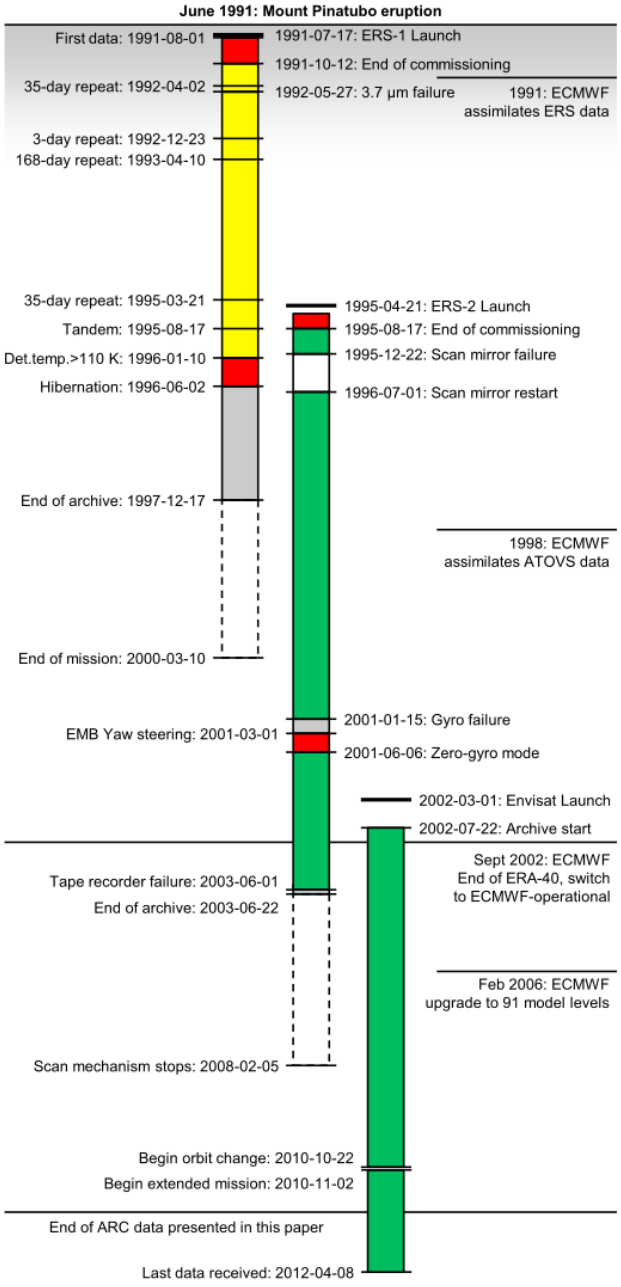
(4) Spectroscopie de l'Atmosphère, Service de Chimie Quantique Photophysique, Univ. Libre de Bruxelles, Brussels, Belgium

Outline

- Motivation
- Quick introduction to the collocated IASI and AATSR data record
- Aerosol detection for IASI
- Initial results
- Future work

Motivation

- SST is ECV within the GCOS.
- Due to radiometric stability/high characterised nature of IASI and the Metop series of platforms, allows for a CDR of SST from IASI spanning ~20 years.
- This is significant because of the potential of an independent (all-sky -> PWLR3) CDR of SST – but also for bridging (A)ATSR –> SLSTR gap.
- (A)ATSR record is considered a FCDR



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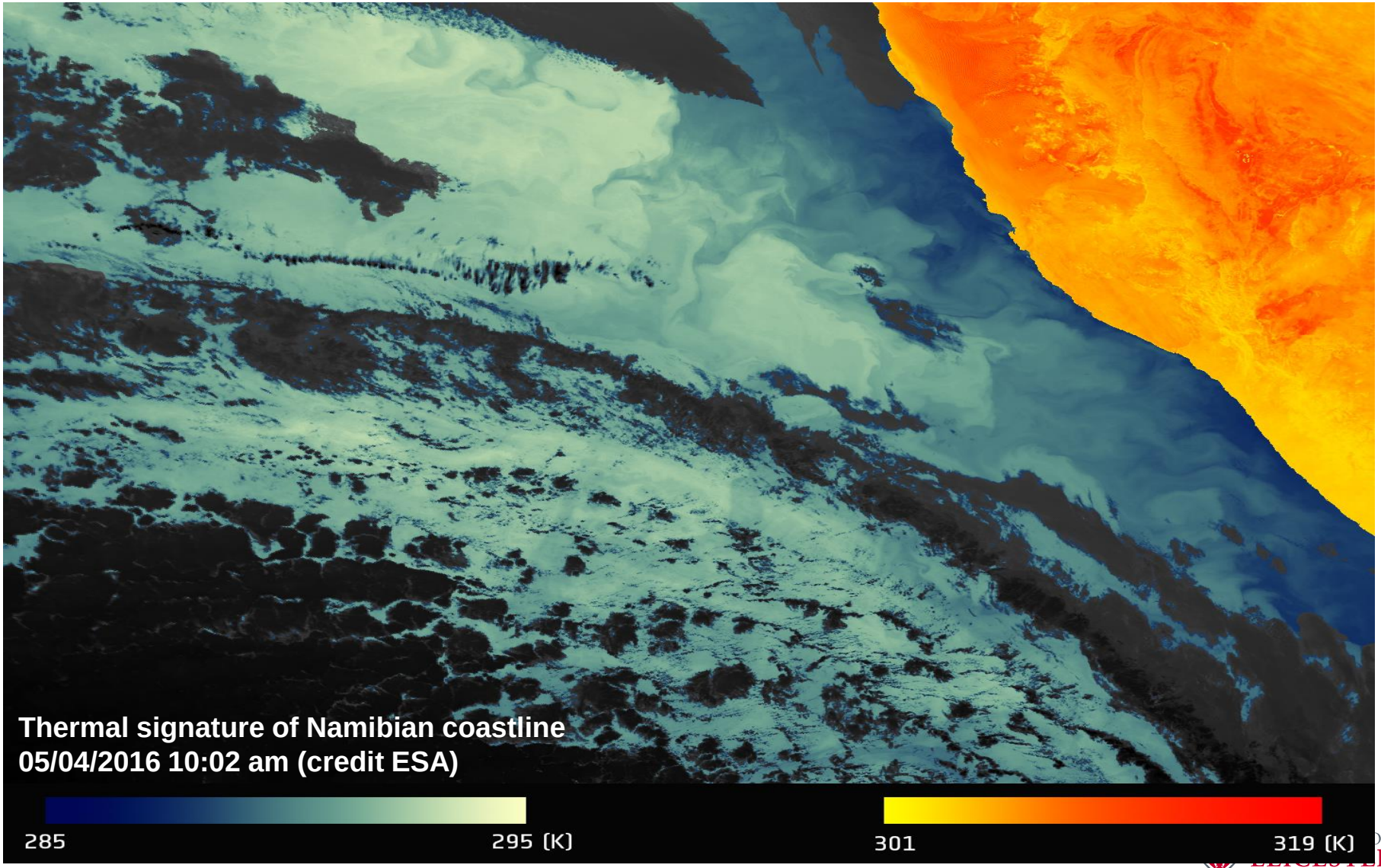
Motivation


Thermal signature of Namibian coastline
05/04/2016 10:02 am (credit ESA)
285
295 [K]
301
319 [K]

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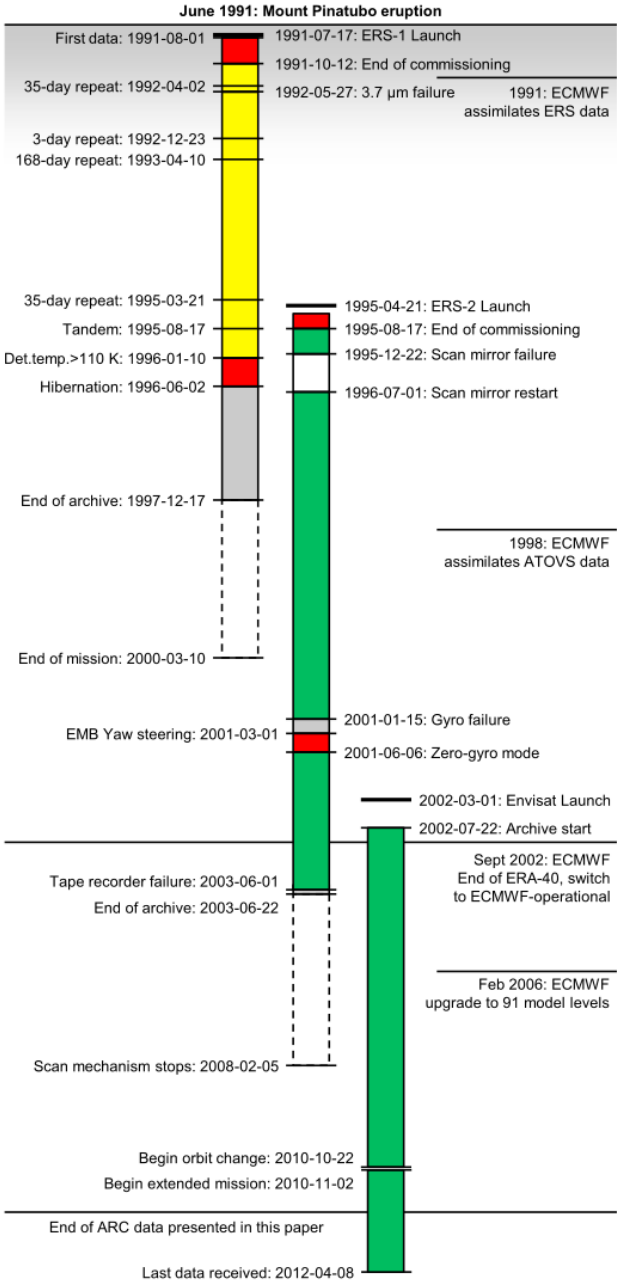

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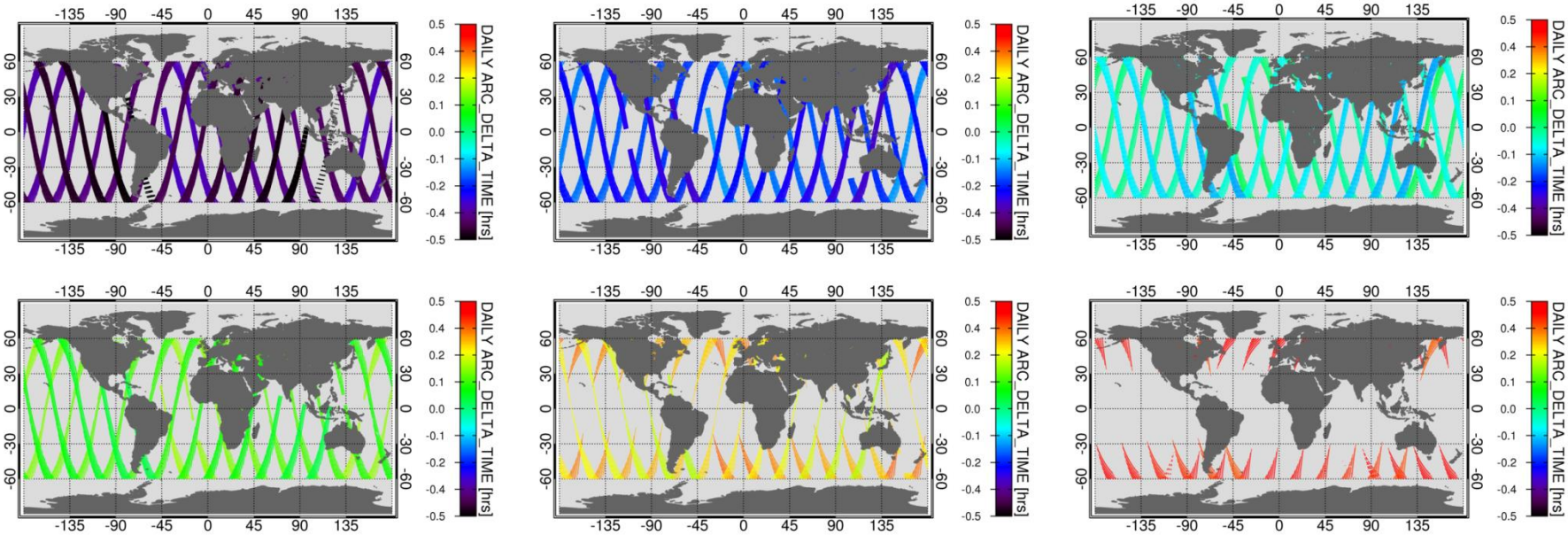
Motivation

- There is a demonstrable need to quantify the absolute performance of IASI SST.
- Because of the overlap between ENVISAT and MetOp-A missions and ~30 min difference in orbits, (A)ATSR can be used for assessing IASI SST.



(6th June 2008 - 11th June 2008)

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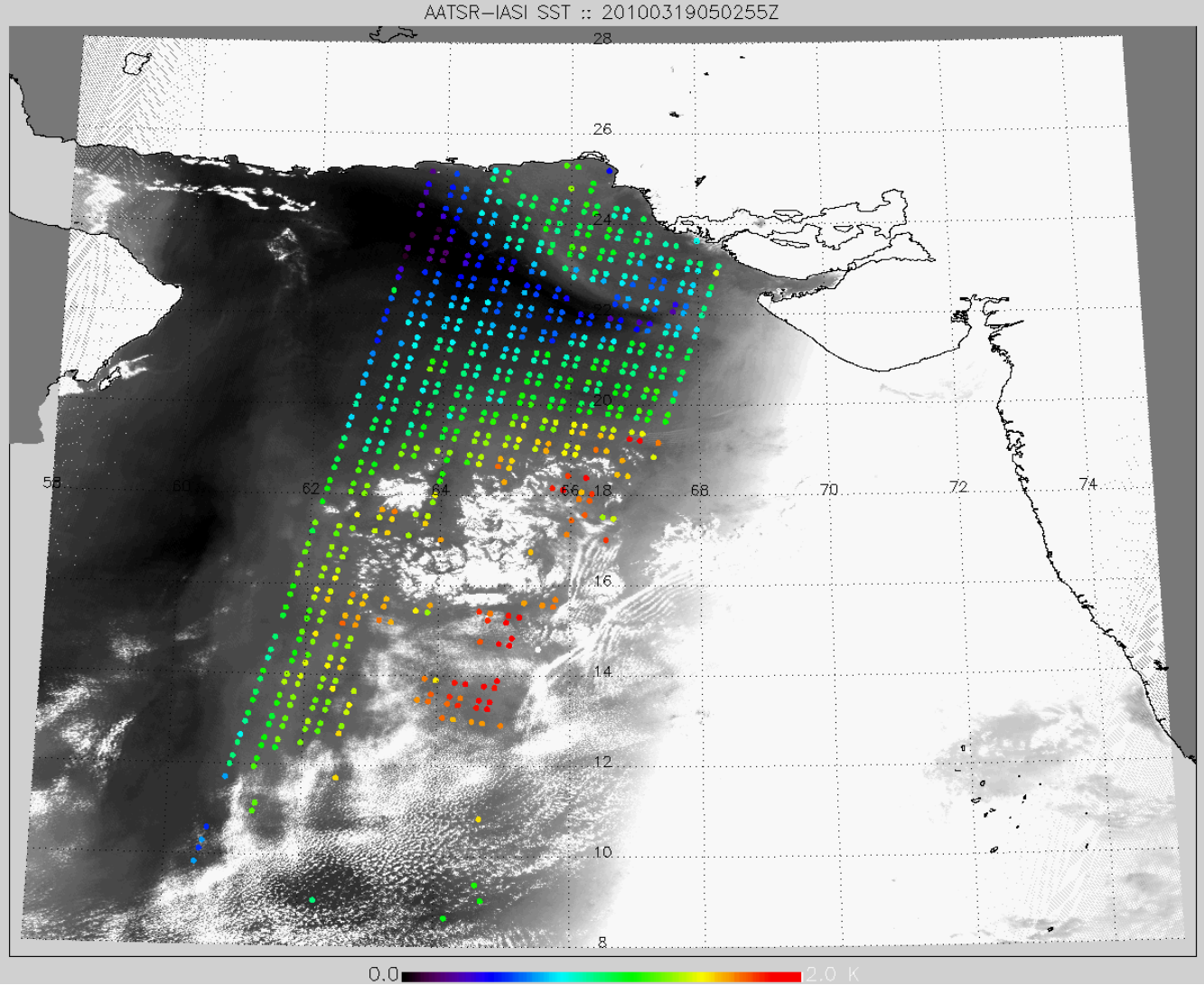
Motivation

- There is a demonstrable need to quantify the absolute performance of IASI SST.
- Because of the overlap between ENVISAT and MetOp-A missions and ~30 min difference in orbits, (A)ATSR can be used for assessing IASI SST .
- (A)ATSR also produces aerosol and cloud products that can be used in these assessments.
- Products are mature and feature in ESA CCI projects.
- Early comparisons of IASI with (A)ATSR showed SST sensitivity to aerosol

Motivation: Why Aerosol?



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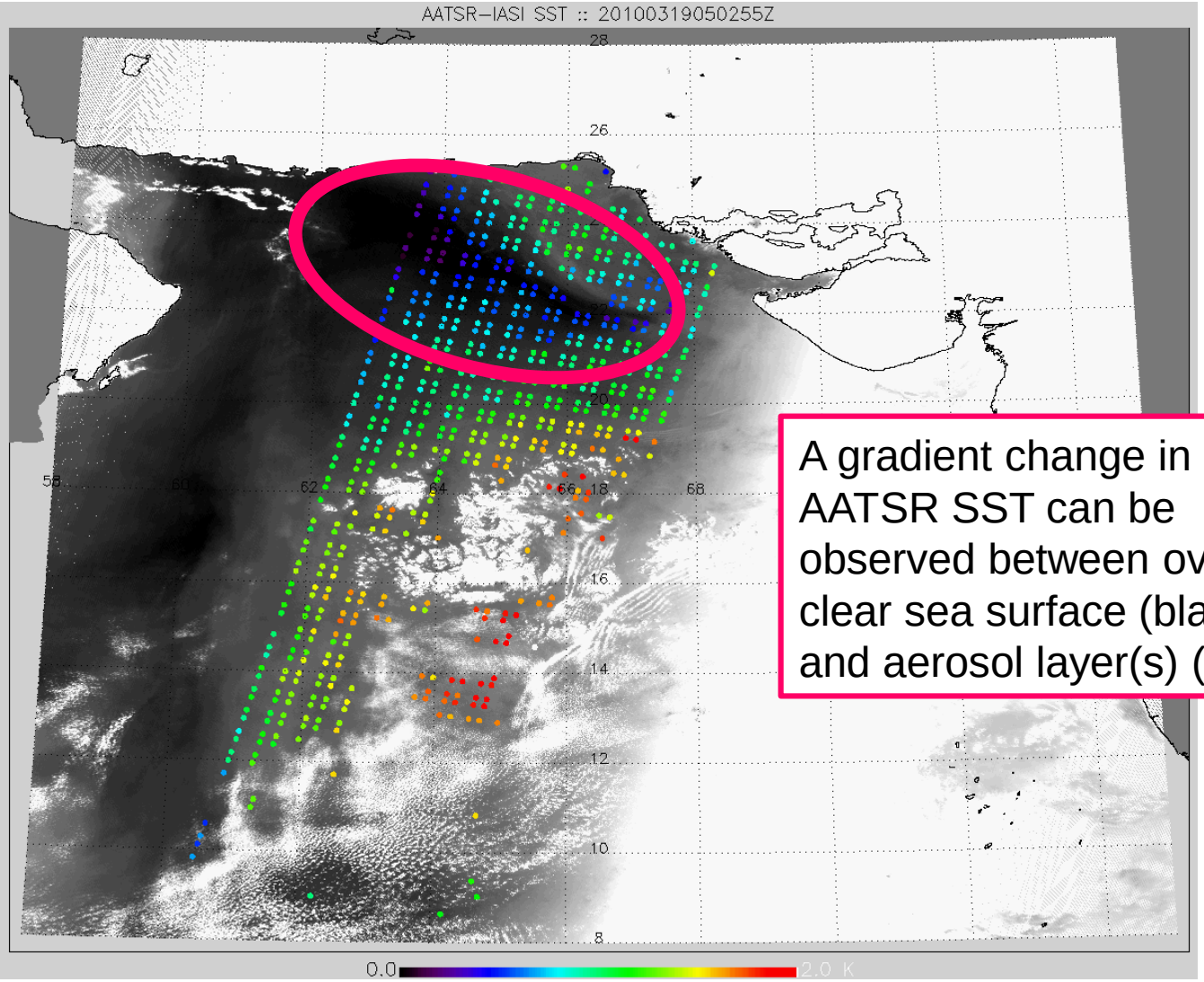

A gradient change in IASI – AATSR SST can be observed between over the clear sea surface (black) and aerosol layer(s) (grey)

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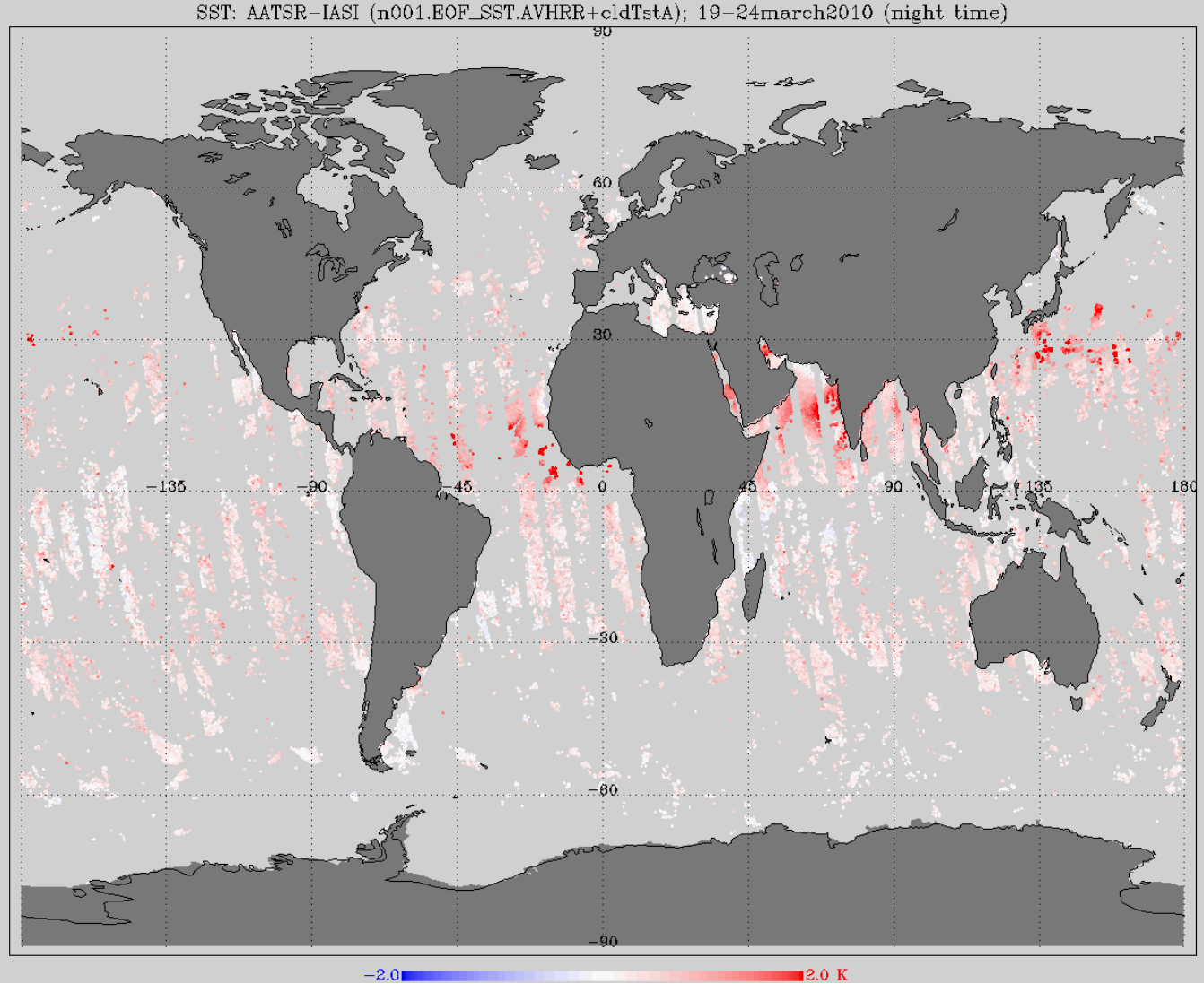

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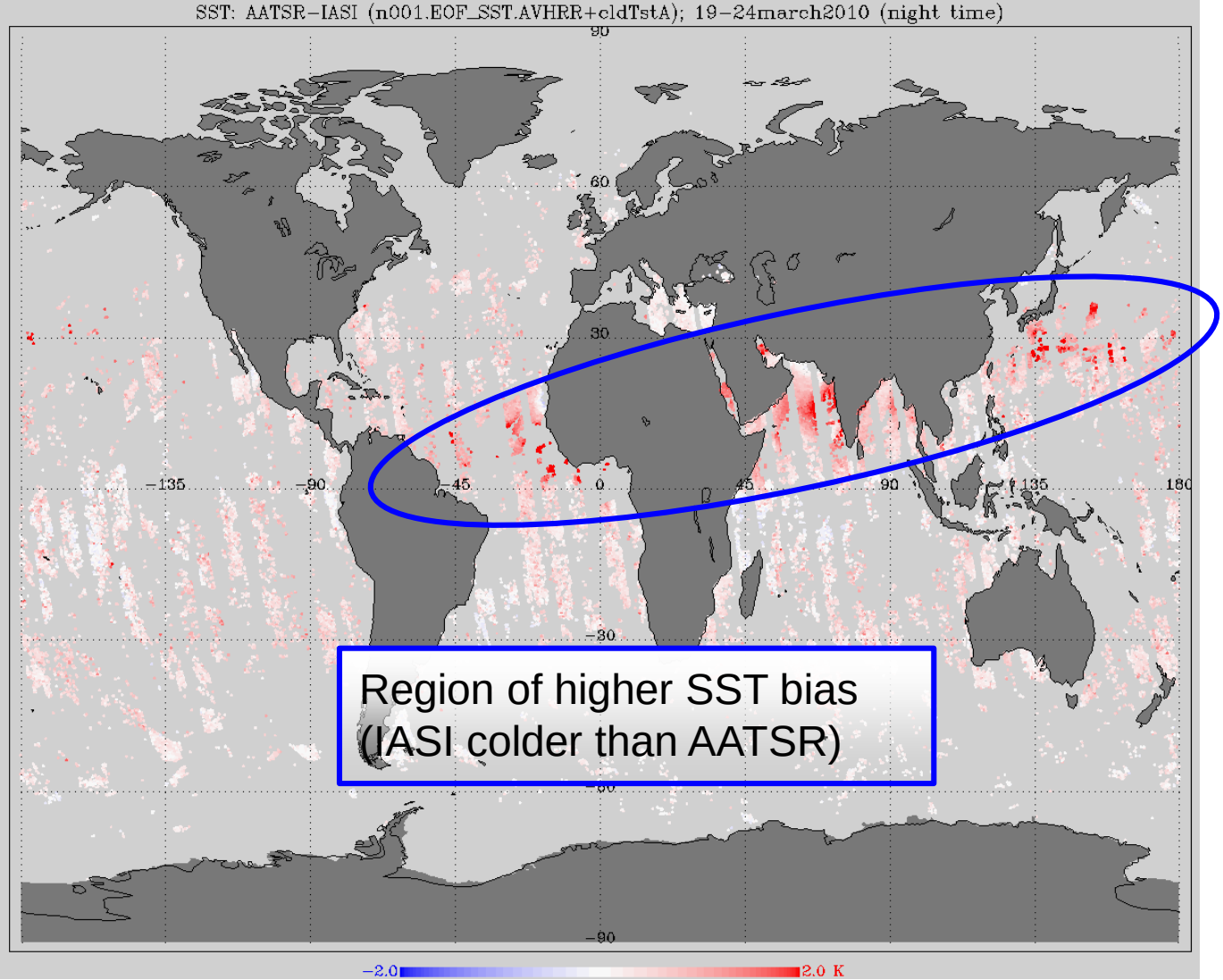
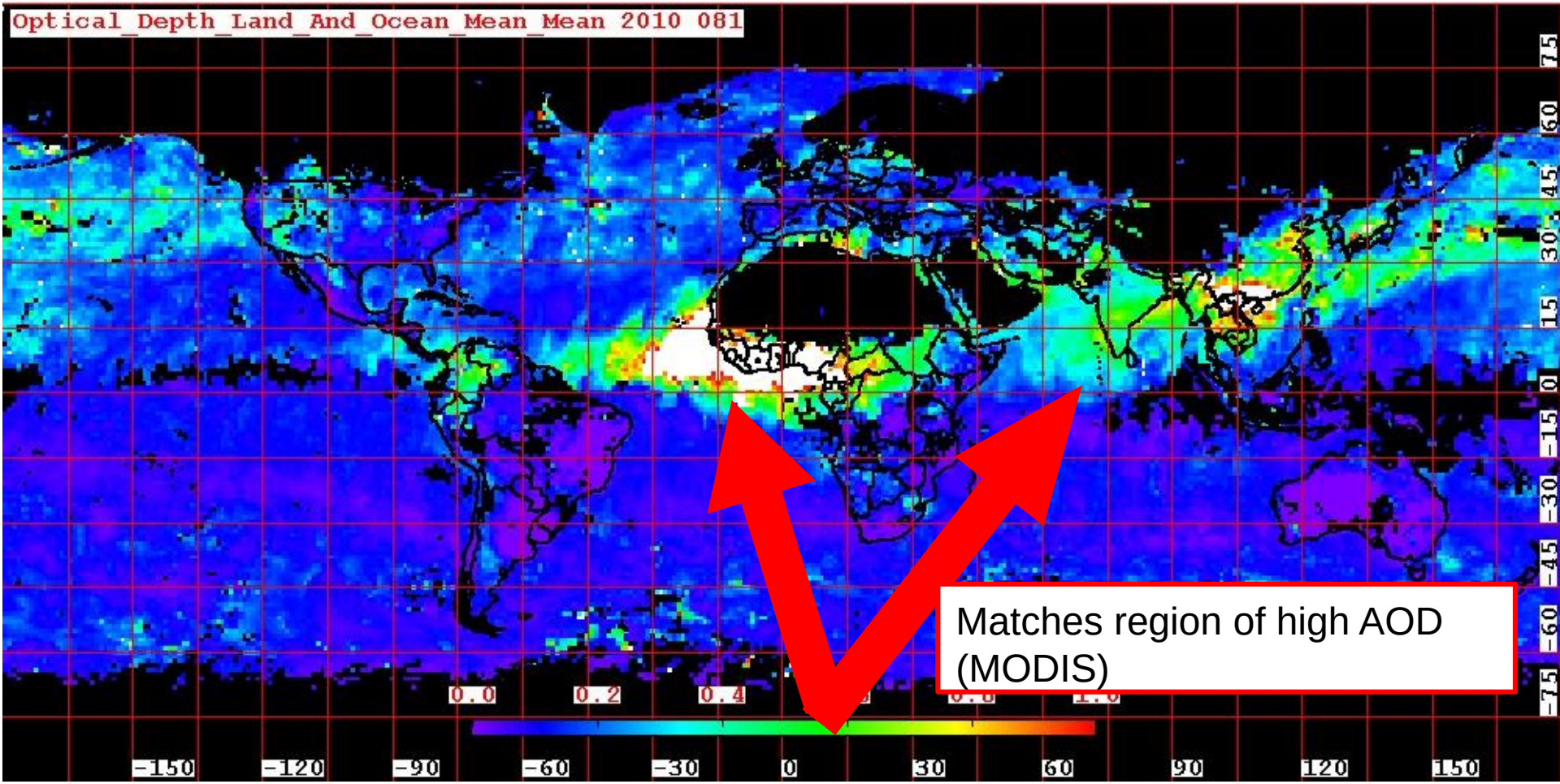


Region of higher SST bias
(IASI colder than AATSR)

Motivation: Why Aerosol?



Augmented IASI PRP Files

- Original IASI PRP files (h5 format) used for collocation of AATSR SST (ARC) and aerosol (ORAC) products.
- IASI (PWLR3) L2 products (Ts, TCWV, uncertainties) extracted to form additional data layers.

PWLR-3 - exploiting horizontal correlation in PieceWise Linear Regression

Hultberg Tim (EUMETSAT)

10:25
(Thursday)

- 60+ variables
- Data exists for 01/10/2007-31/12/2008 (P1) and 01/03/2011 - 31/03/2012 (P2)

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Augmented IASI PRP Files

- ARC
  - SST, (detailed) uncertainty budget, ASDI, ERA Interim wind, cloud (clear-sky probability) and pixel information.
  - L2P_Flag: Description of retrieval type:
    - **D3 = dual-view/3 channel**
    - **D2 = dual-view/2 channel**
    - **N2 = nadir view/2 channel**
  - L2P_Qual: Histogram of GHRSST quality level indicator (1-5) within IFOV:
    - **1=bad_data**
    - **2=worst_quality**
    - **3=low_quality**
    - **4=acceptable_quality**
    - **5 =best_quality**

Top Level	1st level	2nd level
ARC	SST	SST_MEAN
		SST_SIGMA
		SST_IQR
	SST_UNCERT	MEAN_RET_UNCERT
		SIGMA_RET_UNCERT
		IQR_RET_UNCERT
		MEAN_SYN_COR_UNCERT
		SIGMA_SYN_COR_UNCERT
		IQR_SYN_COR_UNCERT
		MEAN_RAD_UNCERT
		SIGMA_RAD_UNCERT
		IQR_RAD_UNCERT
	ASDI	ASDI_MEAN
		ASDI_SIGMA
		ASDI_IQR
	ERA_WIND	WSPEED_MEAN
		WSPEED_SIGMA
		WSPEED_IQR
	CLOUD	CLEAR_PROB
		CLEAR_MEAN
		CLEAR_SIGMA
		CLEAR_IQR
	PIXEL_INFO	NUM_PIXELS
		NUM_PIXELS_USED
		MEAN_DX
		MEAN_DT
		L2P_FLAG
		L2P_QUAL

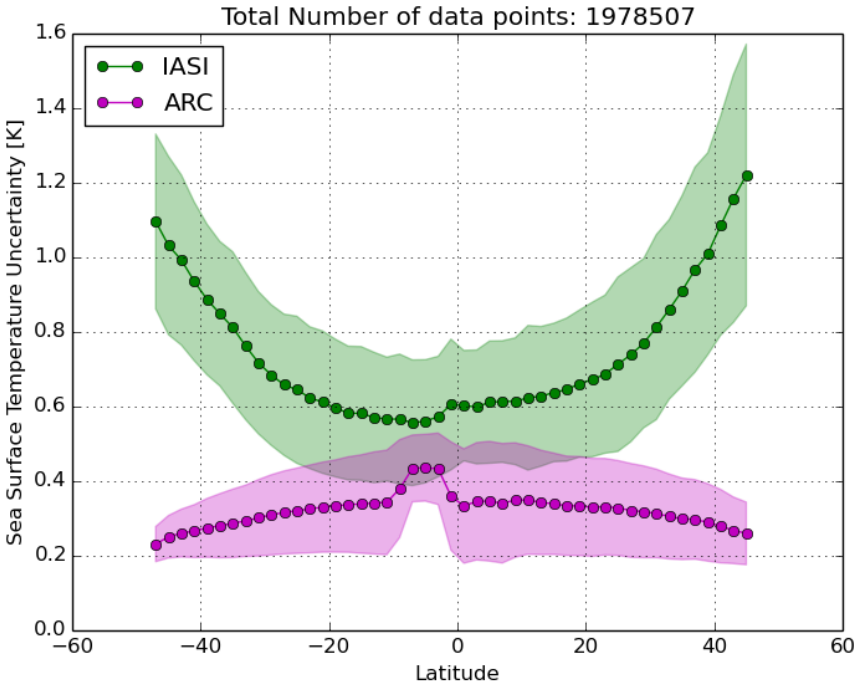
Augmented IASI PRP Files

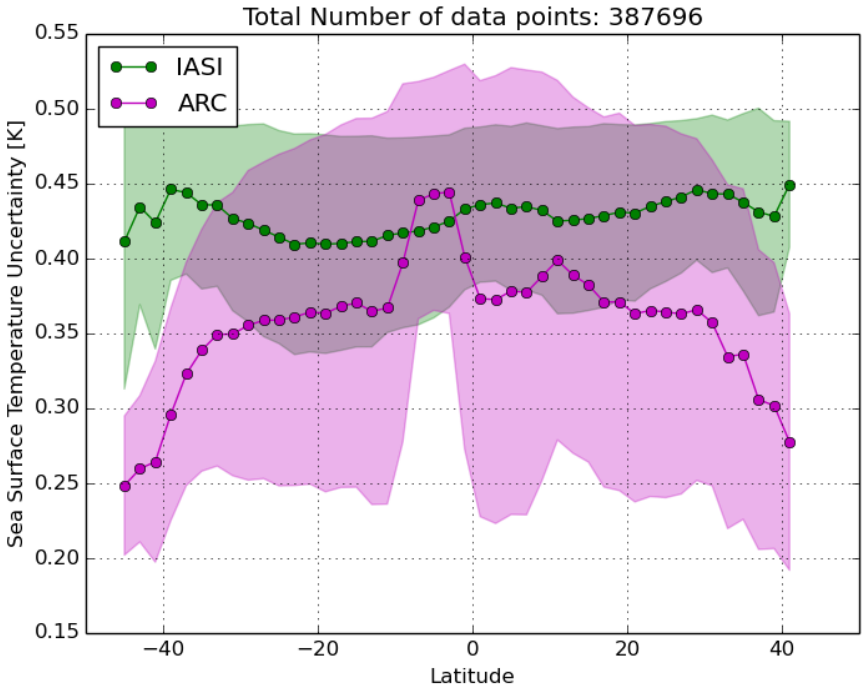
- ORAC
  - Aerosol and cloud information AOD 550, 670, 870, 1600 nm, AOD uncertainty 550 and 870 nm and pixel information.
  - Information on retrieval quality and number of views e.g. 1 or 2.
  - Best-guess aerosol types for IFOV= **A70 A71 A72 A73 A74 A75 A76 A77 A78 A79**
  - Algorithms tend to screen out some high Aerosol loading as cloud. High cases tend to be for the high dust ratio mixing states e.g. **A70-A73**

Top Level	1st level	2nd level
ORAC	AEROSOL_INFO_AND_CLOUD	IFOV_AEROSOL_TYPES
		WEIGHTED_IFOV_ANG550_870
		WEIGHTED_IFOV_CLD_FRACT
		WEIGHTED_IFOV_R_EFF
		WEIGHTED_IFOV_R_EFF_ERR
	AOD	WEIGHTED_IFOV_AAOD550
		WEIGHTED_IFOV_AOD1600
		WEIGHTED_IFOV_AOD550
		WEIGHTED_IFOV_AOD550_ERR
		WEIGHTED_IFOV_AOD670
		WEIGHTED_IFOV_AOD870
		WEIGHTED_IFOV_AOD870_ERR
		WEIGHTED_IFOV_D_AOD550
		WEIGHTED_IFOV_FM_AOD550
	PIXEL_INFO	IFOV_ITERATIONS
		IFOV_NPIXELS_USED
		IFOV_QFLAGS
		IFOV_SURF_TYPES
		IFOV_VIEWS
		IFOV_WEIGHTS
		WEIGHTED_IFOV_DT
		WEIGHTED_IFOV_DX
		WEIGHTED_IFOV_FIT_ERROR
		WEIGHTED_IFOV_SAT_ZEN
		WEIGHTED_IFOV_SOL_ZEN

Quality control of Matches

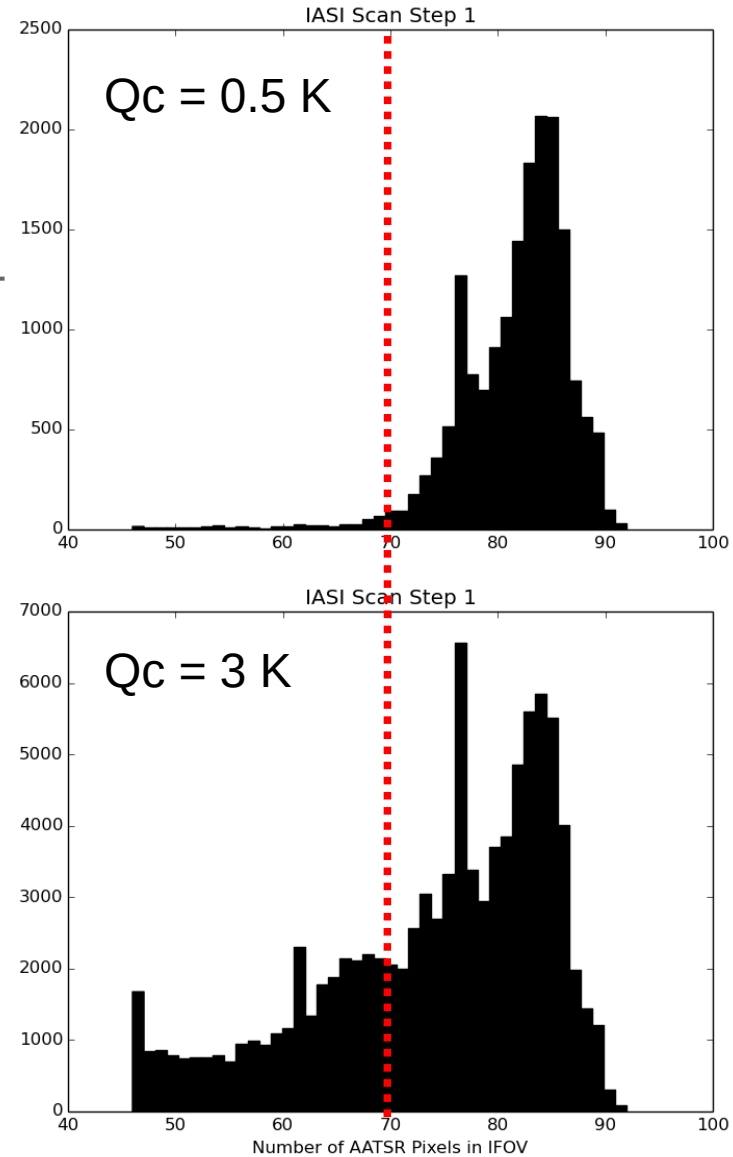
- Currently threshold of 3 K placed on SST retrievals.
- Latitudinal dependence.
- Restricting the SST retrieval uncertainty does improve the mean SST uncertainty globally – more comparable with ARC.
- However, you lose ~80% of data points.





Quality control of Matches

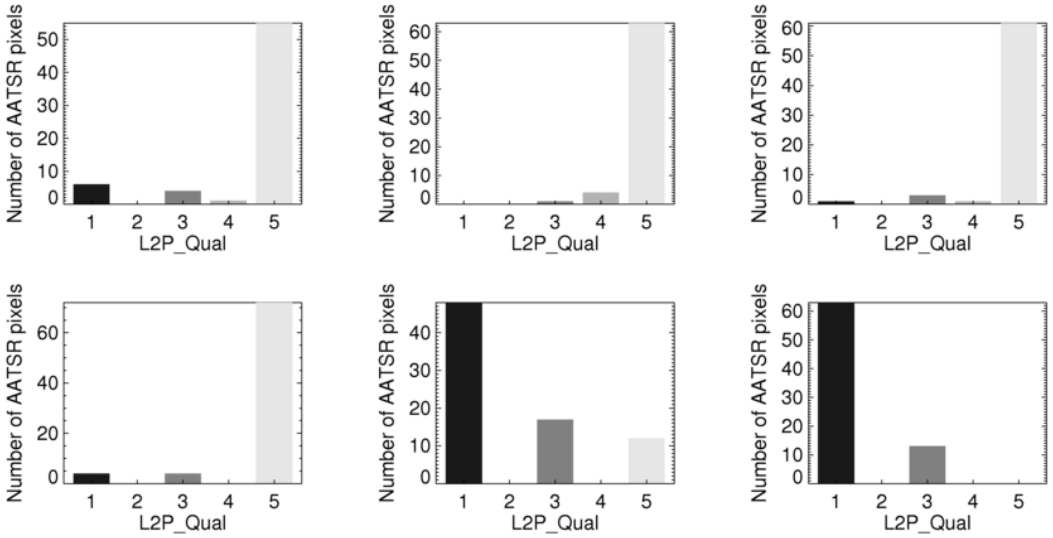
- Minimum number (per scan step) threshold to ensure representation within IASI IFOV.
- Histogram of distributions based to 2 SST uncertainty thresholds (0.5 and 3 K).

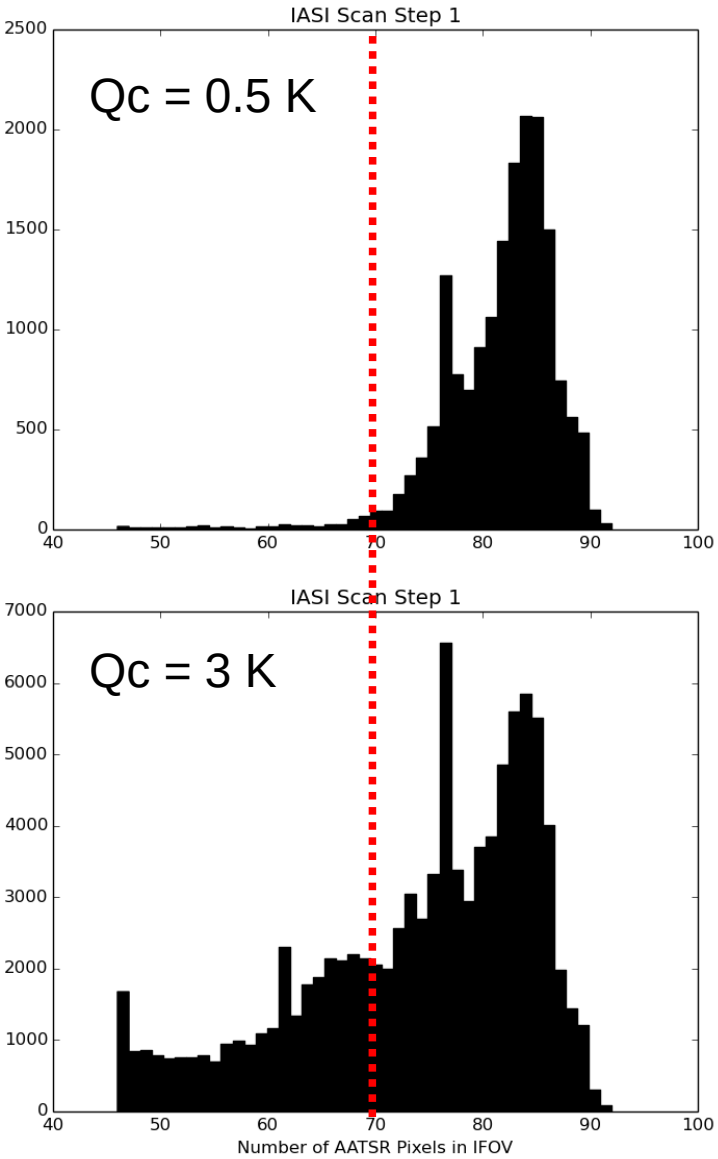


Step Number	No of AATSR Pixels	Step Number	No of AATSR Pixels
01	70	09	115
02	70	10	130
03	75	11	145
04	75	12	180
05	80	13	230
06	85	14	300
07	90	15	425
08	105		

Quality control of Matches

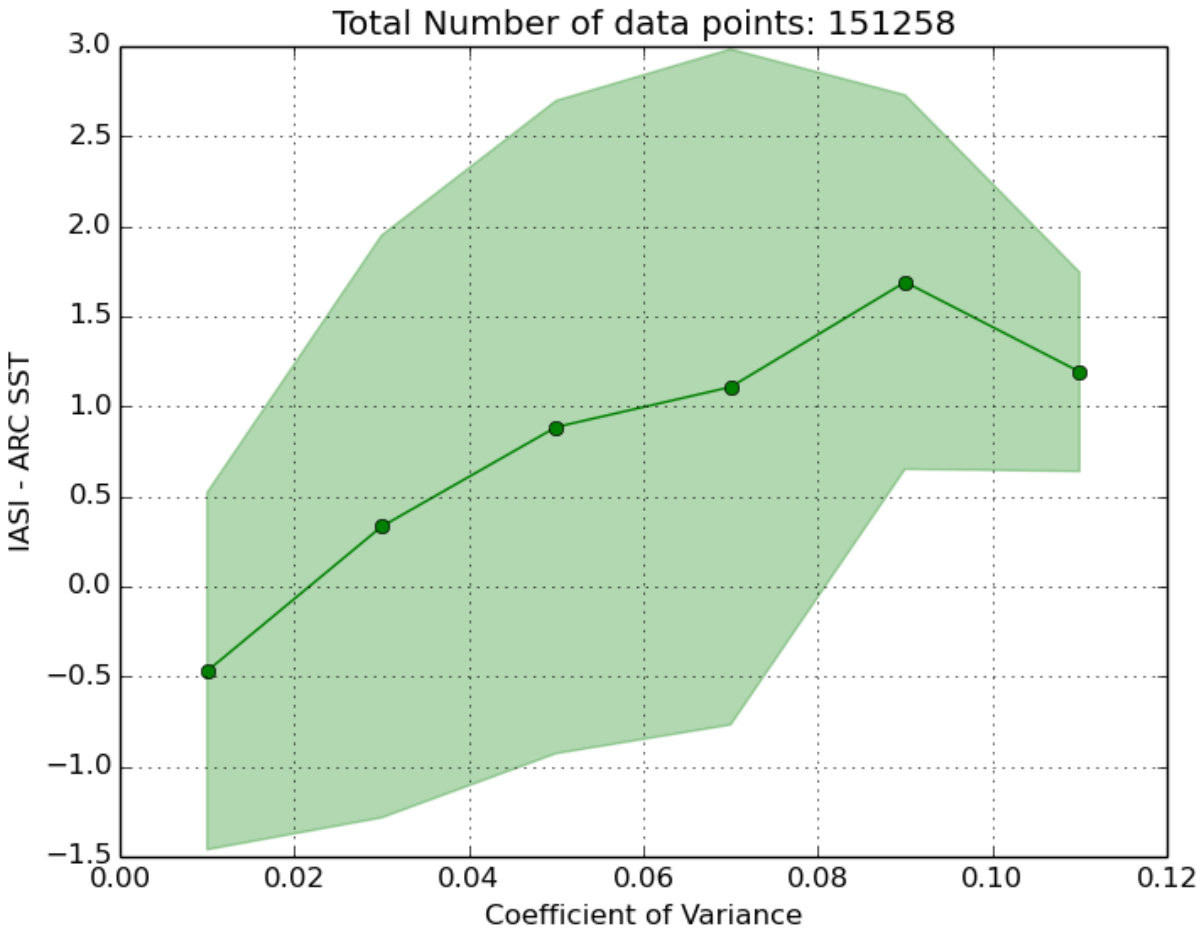
- Minimum number (per scan step) threshold to ensure representation within IASI IFOV.
- Histogram of distributions based to 2 SST uncertainty thresholds (0.5 and 3 K).
- Minimum of 30 % of pixels used must be of best quality.





Quality control of Matches

- Finally, look at how heterogeneity effects bias by looking at coefficient of variance within IFOV.
- CV = σ/(μ-273.15)
- A 10% change in variance can have ~1 K impact on the bias
- Threshold of 2% CV used as quality control for collocated ARC SST.



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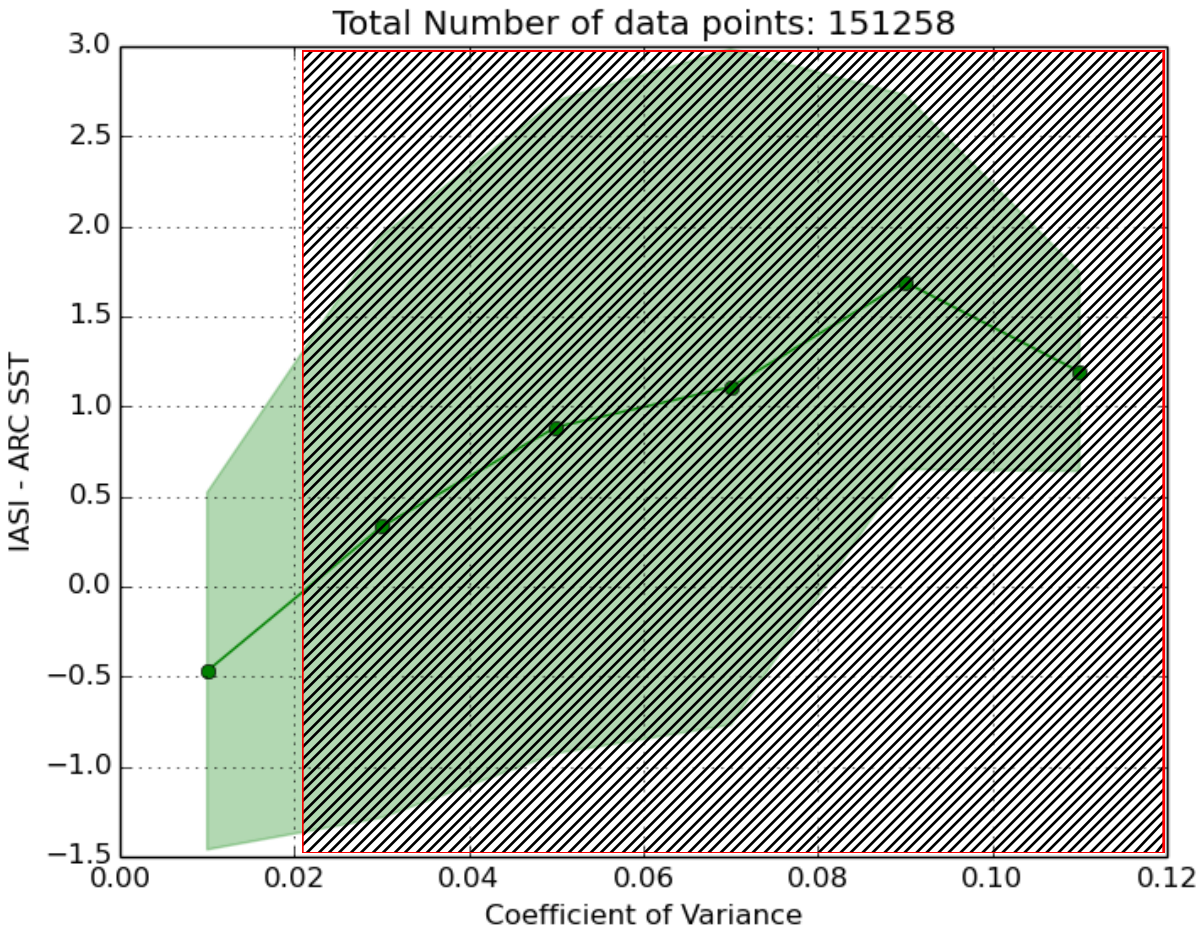
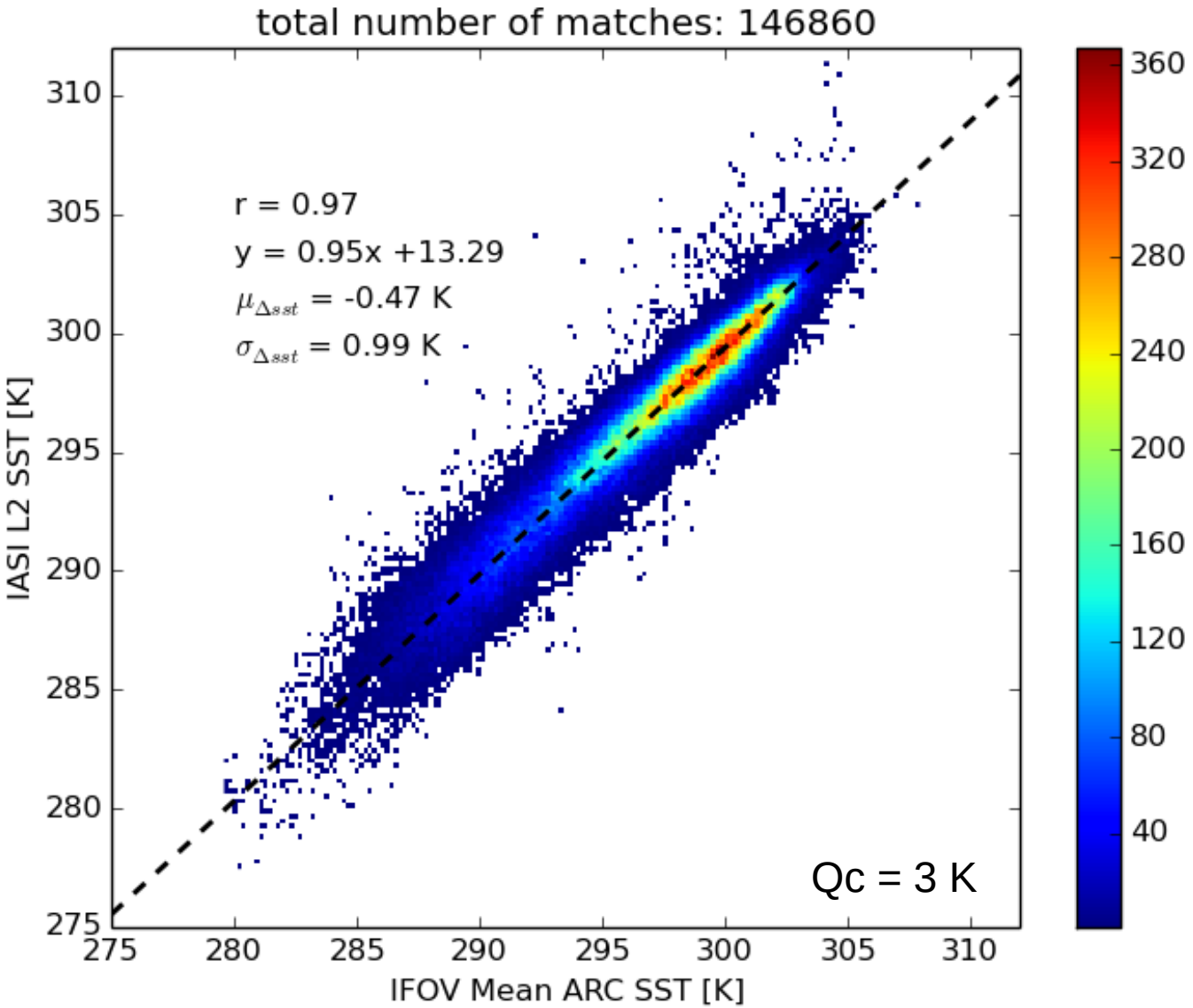


Initial Results: (Clear sky, daytime only)



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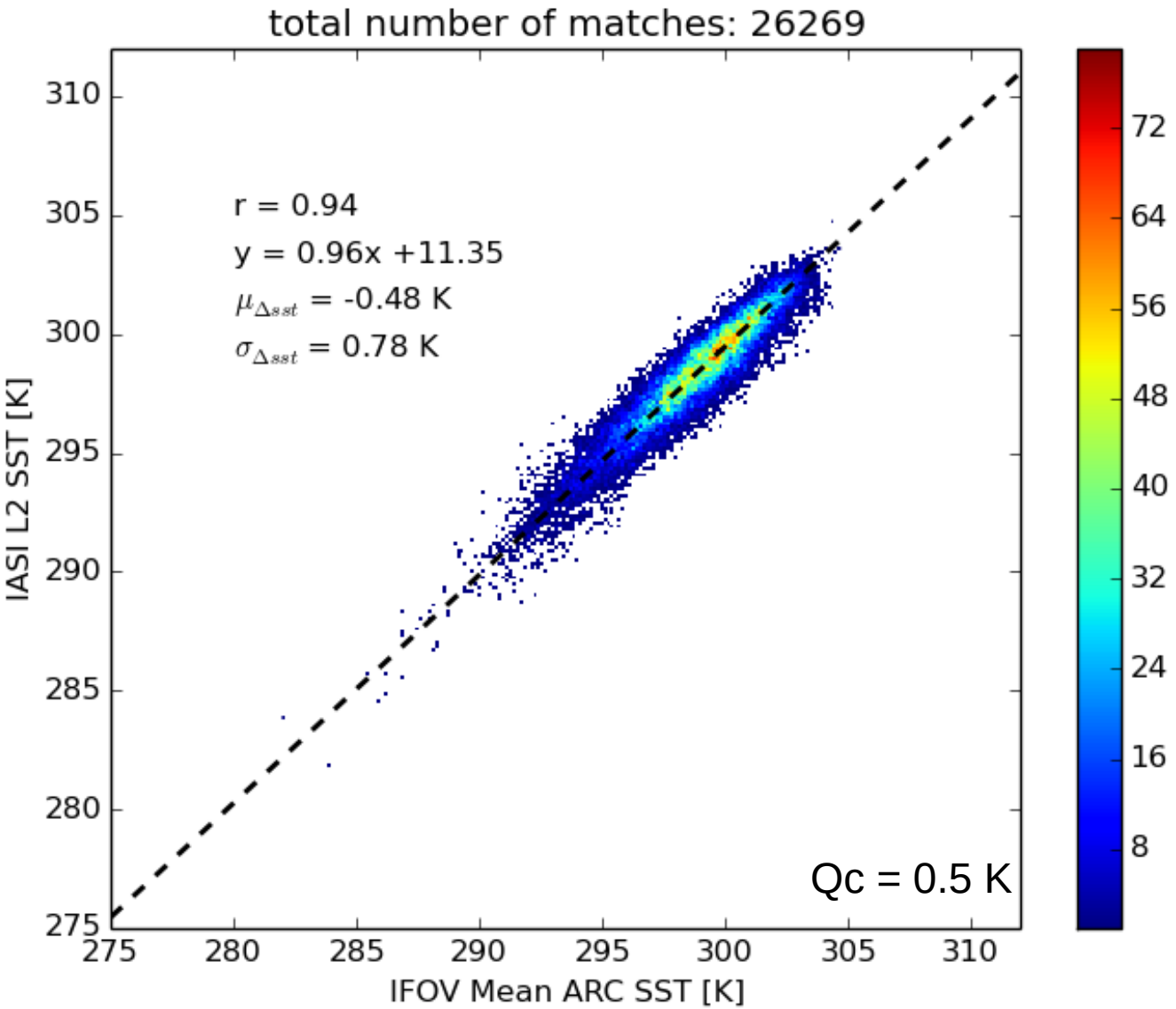
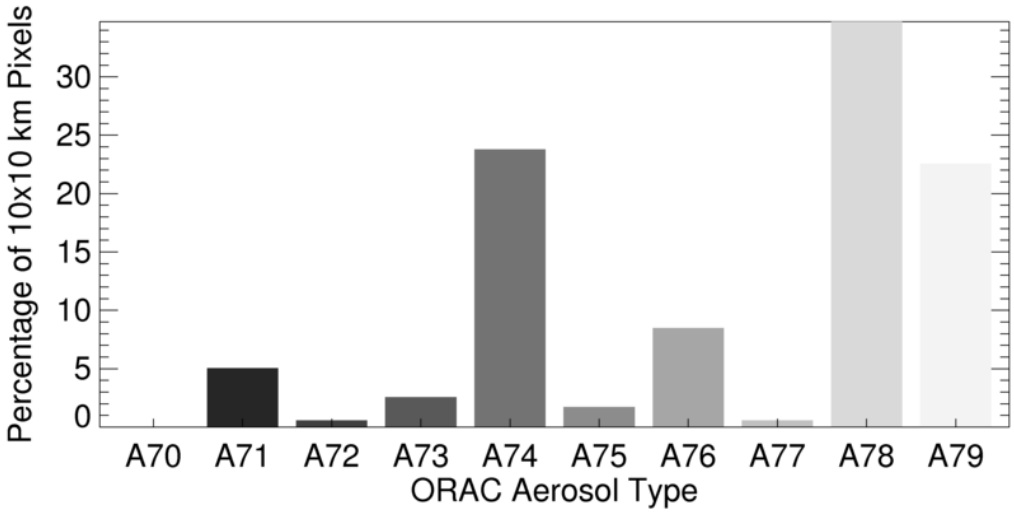


Initial Results: ORAC Aerosol Type

- The ORAC product categorises the aerosol retrieval into 10 classes (CCI).
- Information is stored as histogram within the augmented IASI PRP files.
- Flag for mode value in IFOV created.
- IASI SST biases can be investigated as a function of these 10 classes



Name	Mixing state Fine:Coarse	Coarse		Fine		Re (µm)
A70	99.0:1.0	100%	dust	12.50%	strongly-absorbing	1.218
A71	99.8:0.2	100%	dust	50%	strongly-absorbing	0.553
A72	99.8:0.2	75%	dust	25%	strongly-absorbing	0.553
A73	99.8:0.2	75%	dust	12.50%	strongly-absorbing	0.553
A74	99.8:0.2	50%	dust	100%	weakly-absorbing	0.553
A75	99.5:0.5	25%	dust	100%	weakly-absorbing	0.908
A76	99.0:1.0	100%	sea-salt	100%	weakly-absorbing	1.218
A77	99.5:0.5	50%	dust	12.50%	strongly-absorbing	0.908
A78	99.8:0.2	100%	sea-salt	12.50%	strongly-absorbing	0.553
A79	100.0:0.0	-		37.50%	strongly-absorbing	0.142

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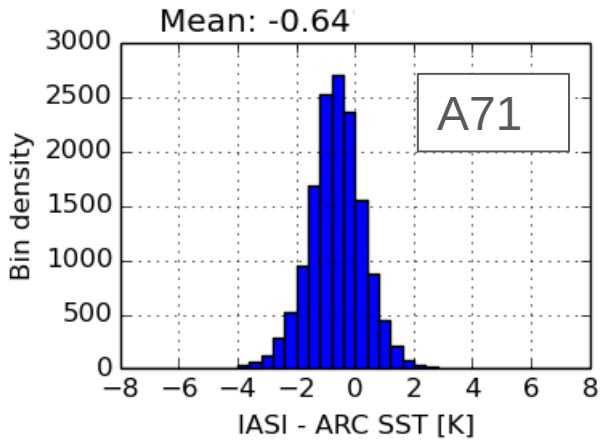
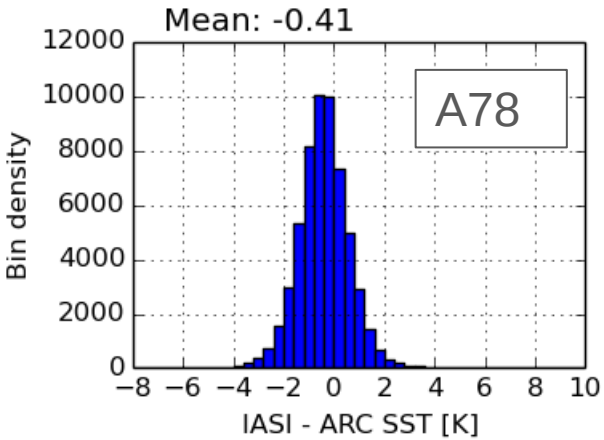
- E.g. ~0.2 K between A71 and A78





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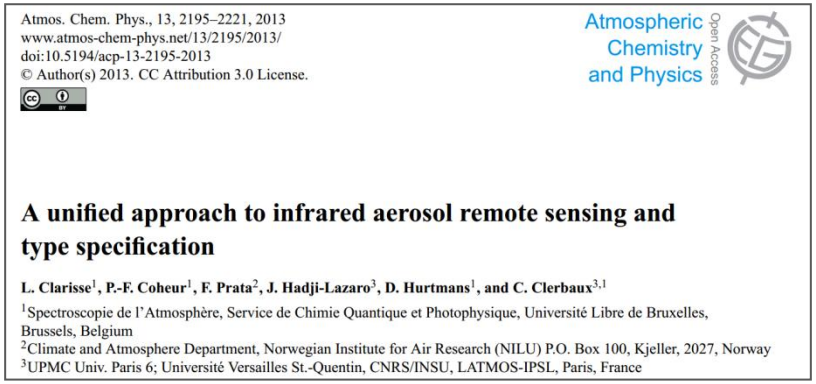
IASI Aerosol Index

- For full discussion refer to:


Atmos. Chem. Phys., 13, 2195–2221, 2013
www.atmos-chem-phys.net/13/2195/2013/
doi:10.5194/acp-13-2195-2013
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Atmospheric Chemistry and Physics
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A unified approach to infrared aerosol remote sensing and type specification

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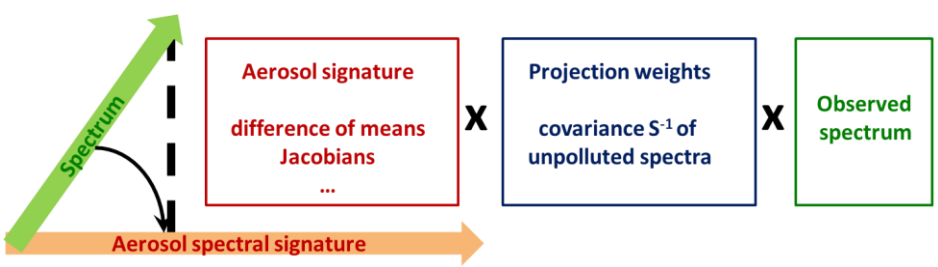
[1]Spectroscopie de l'Atmosphère, Service de Chimie Quantique et Photophysique, Université Libre de Bruxelles, Brussels, Belgium
[2]Climate and Atmosphere Department, Norwegian Institute for Air Research (NILU) P.O. Box 100, Kjeller, 2027, Norway
[3]UPMC Univ. Paris 6; Université Versailles St.-Quentin, CNRS/INSU, LATMOS-IPSL, Paris, France

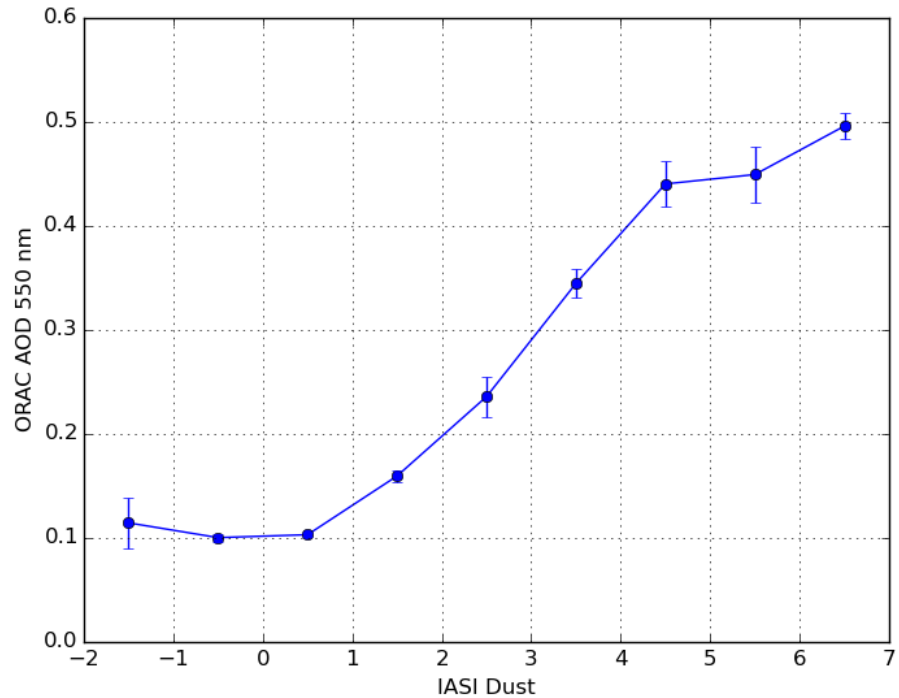
- Linear discrimination analysis (LDA):

$$R = (\mu_k - \mu_l)^T S^{-1}(\mathrm{y})$$

- Weighted least squares (Walker et al, 2010):

$$(k)^T S^{-1}(\mathrm{y})$$





- PCA detection uses different projection weights (Hurley et al., 2009)
- IASI aerosol index is promising as it can be related to AOD

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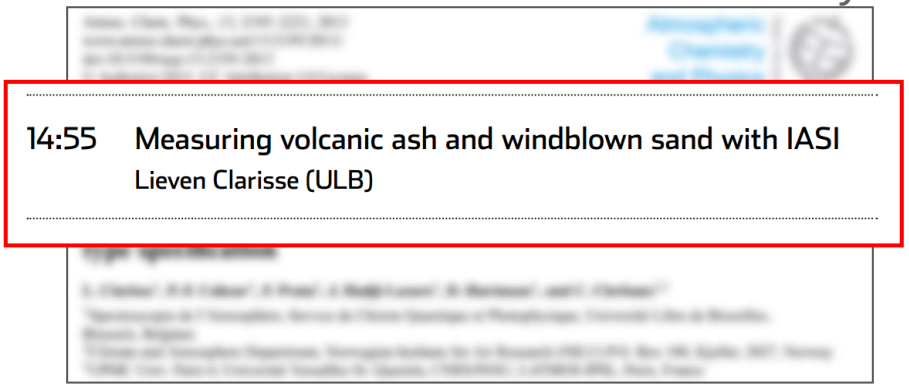
IASI Aerosol Index

- Or see Lieven's talk on Wednesday:



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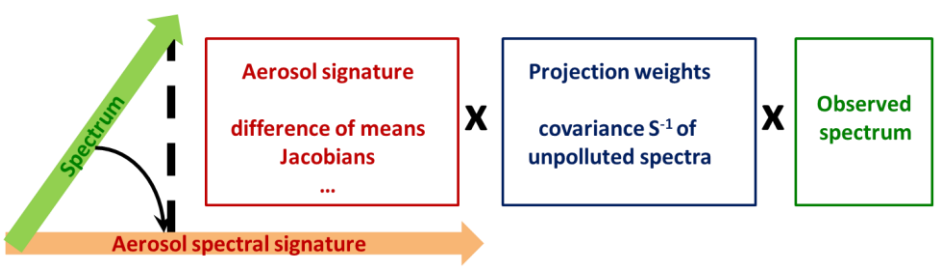

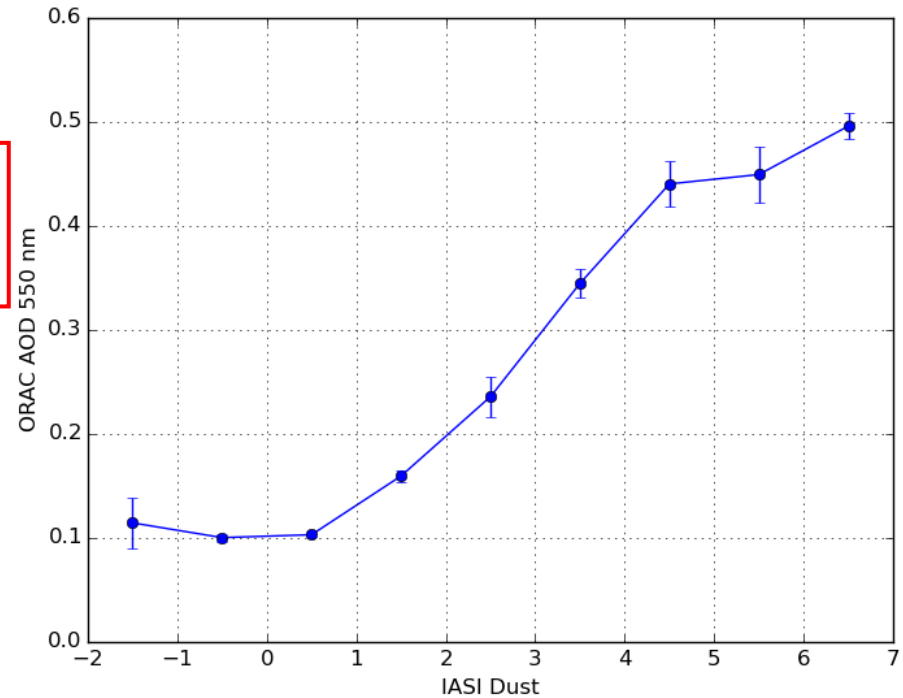

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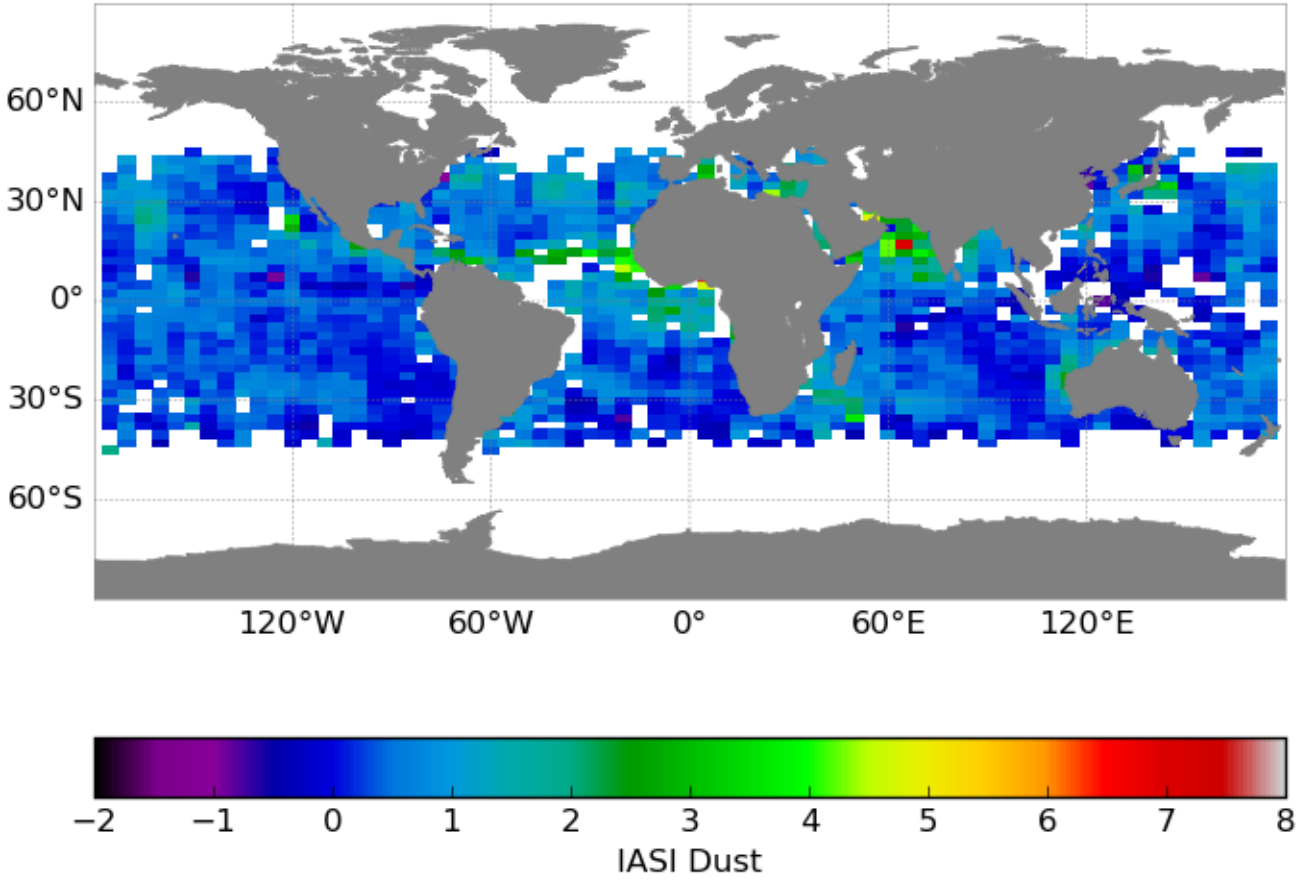

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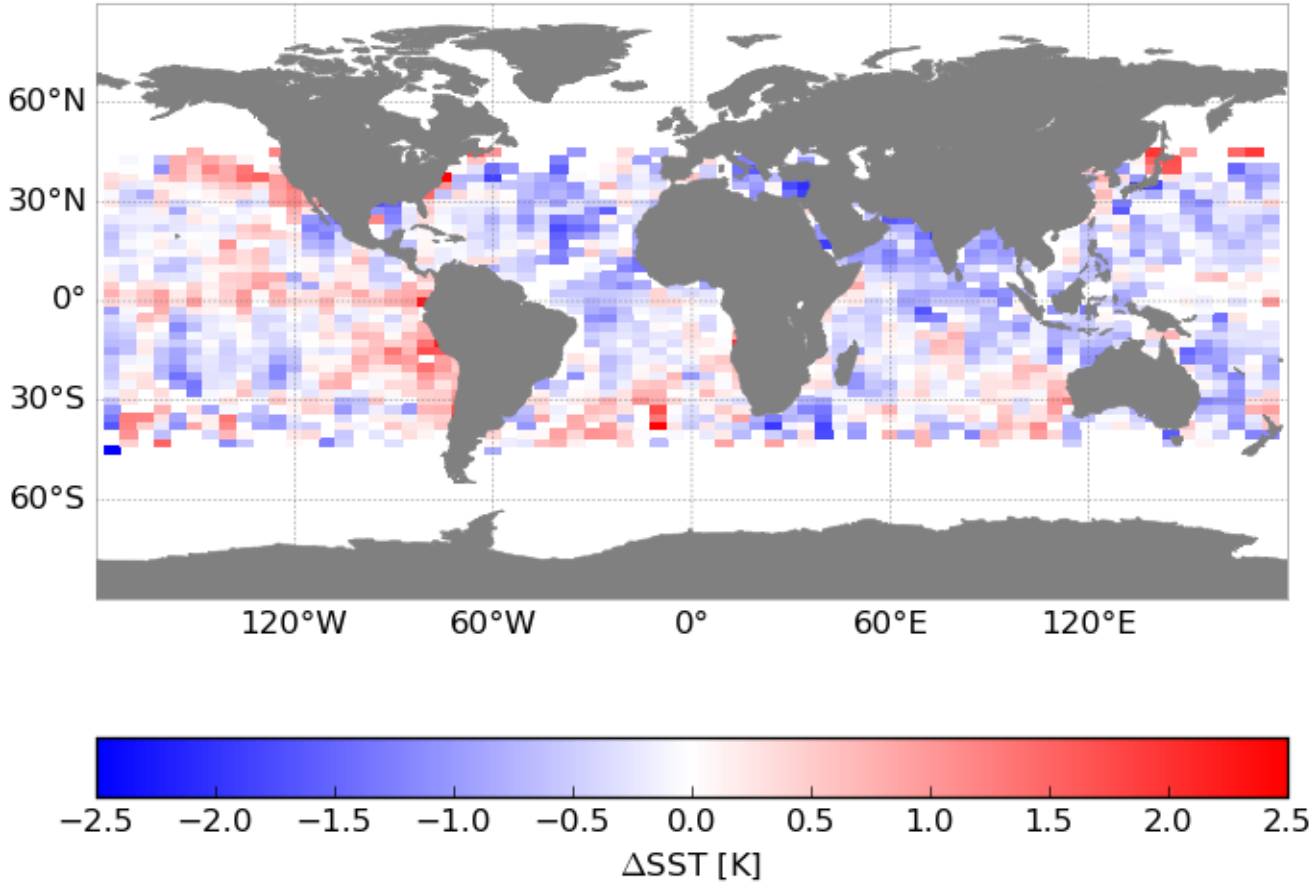
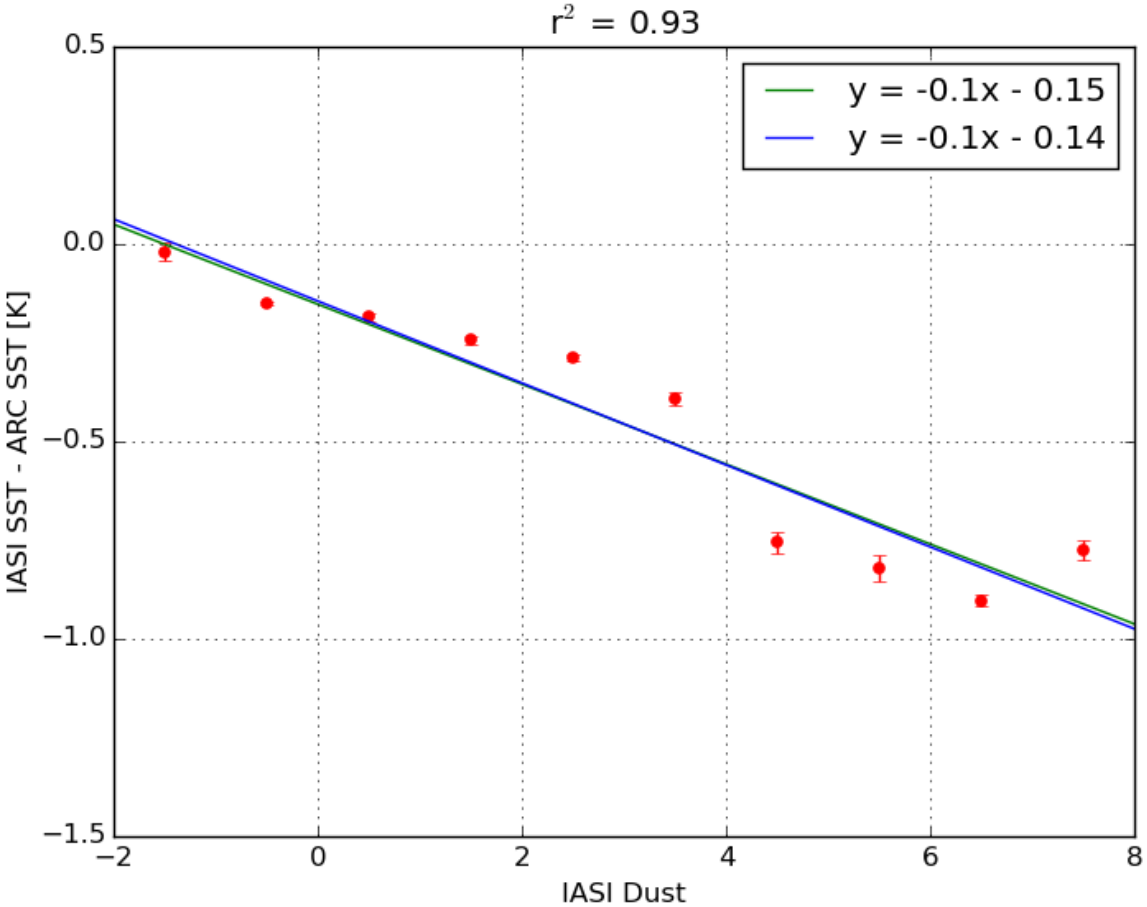


(IASI – (A)ATSR SST)

IASI Aerosol Index

- Results are global and for P1 only.
- All-sky approach (no cloud clearing).
- Dust events can contribute up to ~1 K difference to ARC
- Relationship probably non-linear, need more high dust value (> 3) data points to be sure.



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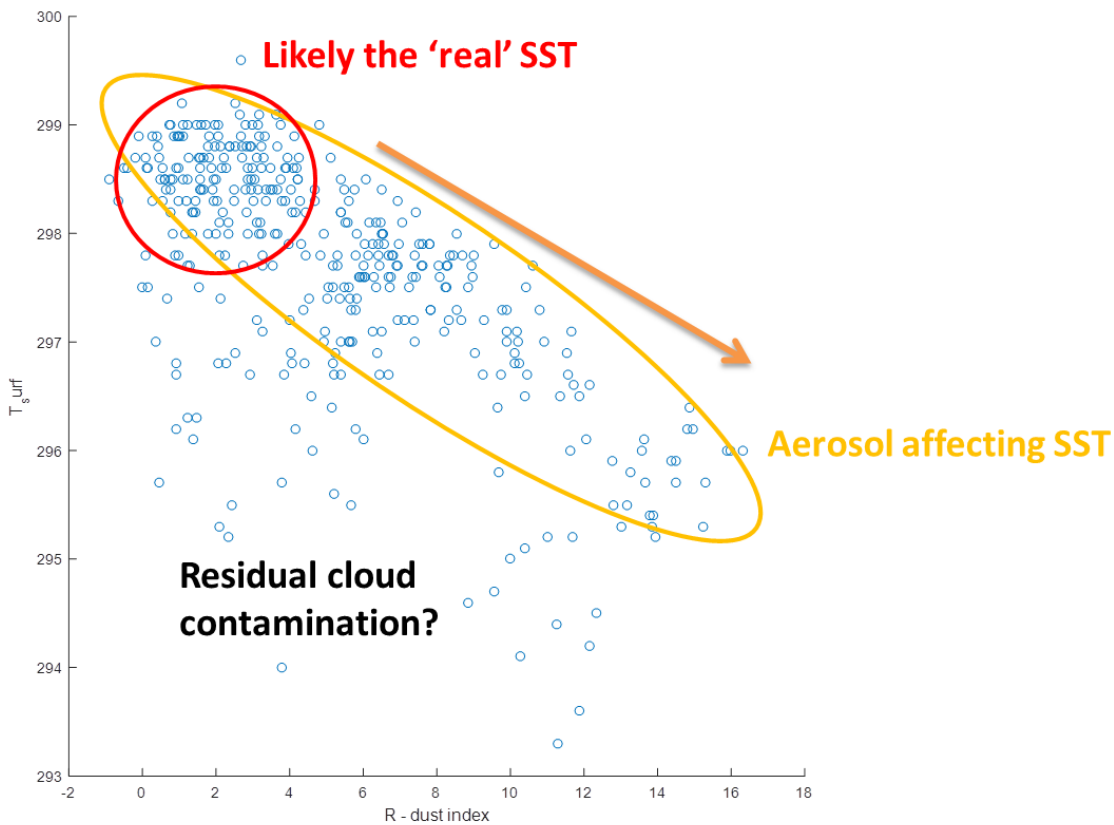

- Influence on retrieved sea surface temperature (IASI L2 NRT).
- June 2013,between 18 and 21 latitude, -50 and -49 longitude
- For such a small area and time period one can assume a constant surface temperature (here around 298.5?)
- So 1K per R=5 (global ~0.75 K)
- About 3K ~R= 15

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Next Steps:

- Increase our understanding of exactly how we can constrain the SST from IASI aerosol index.
- Obs – Calc analysis using retrieved atmosphere from IASI and SST values from:
    - IASI
    - ARC
    - ECMWF
- This approach is another method to assess the accuracy of IASI SST.
- Test whether the definition of SST (skin vs. bulk).
- If ARC yields a better Obs-Calc then 1st order bias correction can be applied.

Summary:

- Overview of a new collocated IASI – AATSR data set (ITT) with new updated parameters for IASI aerosol and SST.
- Demonstrated the new IASI aerosol index and its similarities to AOD.
- Rationalised and applied quality criteria in 'high scrutiny' mode and discussed impact on remaining variables.
- Demonstrated negative bias in IASI SST with increasing aerosol load. Seen both in AOD and the IASI aerosol index.
- Outlined the approach to applying an empirical correction