S3 Tandem for Climate

SST observations during the SLSTR Tandem Phase

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INTRODUCTION

The Sentinel-3 Tandem phase offers the opportunity the study both differences in the SSTs from two different SLSTRs (Sea and Land Surface Temperature Radiometer) on Sentinel-3A (S3A) and Sentinel-3B (S3B)) as well as to study the impact of different sources of error (such as clouds) for each observation. This is because in the Tandem phase S3A and S3B were flown in a close formation where the minimum time difference was 30 seconds for the same geographic area (within 1km). Given that the SST will not change significantly with a 30 second time gap any observed differences are mainly due to instrumental differences, retrieval errors or changes in the local conditions. Here we show results related to retrieval coefficients, their associated uncertainties, changes in quality levels and biases/uncertainties related to cloud derived using Tandem data.

S3A to S3B SST differences

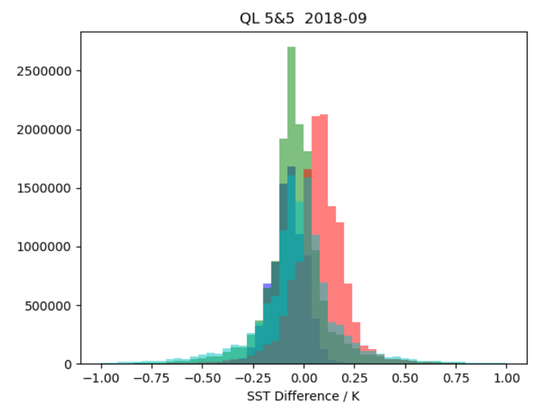

Figure 1. SST differences per retrieval algorithm for quality level 5 data (N2-blue, N3-green, D2-red, D3-cyan)

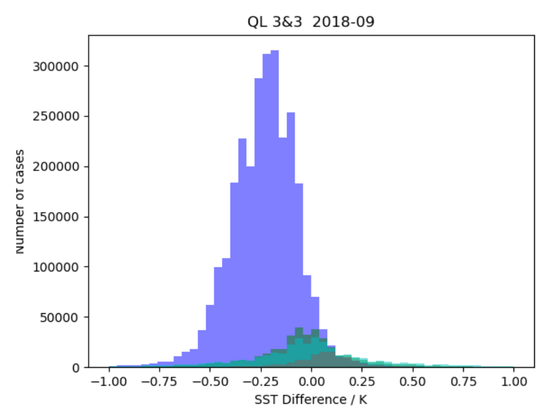

Figure 2. SST differences per retrieval algorithm for quality level 3 data (N2-blue, N3-green, D2-red, D3-cyan)

Figure 1 shows the S3A-S3B SST differences for the quality level 5 data for the four main retrieval algorithms (N2 – nadir view 2 channel, N3 – nadir view 3 channel, D2 – dual view 2 channel, D3 – dual view 3 channel) for a 30 second time gap for three days in Sept. 2018. The differences are generally small and are in part related to the fact that there are errors in the current S3B retrieval coefficients which are the same as those used for S3A. That notwithstanding, such small differences show the two instruments are very closely matched. While it is currently recommended to only use quality level 5 data from SLSTR, looking at other quality levels (Figure 2) indicates that there are particular problems for the N2 retrievals.

SST UNCERTAINTIES

The SLSTR SSTs come with uncertainty information (GHRSST SSES and an ESA CCI SST like theoretical uncertainty) which can also be studied. Here, we have looked at the theoretical uncertainty as the SSES only provides a single value per quality level/algorithm type. We have calculated the ratio of Tandem SST differences to its uncertainty which is a measure of how well the uncertainty captures the variance. Note that Tandem data can only study random uncertainties, but the theoretical uncertainty also includes systematic components meaning the ratio should be somewhat less than one. Figure 3 shows that the N3/D2 retrievals (quality level 5) look sensible, but the N2 retrievals seem to have overestimated uncertainties while the D3 uncertainties are underestimated. Lower quality levels data shows a similar pattern together with variations in the overall sigma (Table 1). The uncertainty model therefore needs reviewing together with some extra, previously unknown components related to the quality level itself.

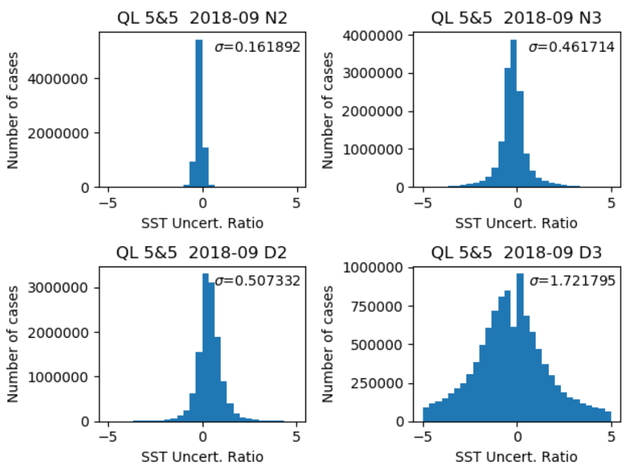

Figure 3. Ratio of SST differences to their uncertainty per retrieval algorithm for quality level 5 data.

Alg. Type	QL==5	QL==4	QL==3
N2	0.16	0.15	0.14
N3	0.46	0.62	0.77
D2	0.50	0.83	0.67
D3	1.72	1.92	2.36

Table 1. Standard deviation of the ratio of SST differences to their uncertainty per retrieval algorithm for a range of quality levels. Three channel algorithms show an increase in the standard deviation indicating a missing source of error as a function of quality level. The two channel case also shows quality level based variability.

Changes to the quality levels

In around 6% of cases, the quality level of a pixel changes when going from S3A to S3B data. Figure 4 shows the distance between an S3A quality level 5 pixel (ql5) and the nearest quality level 3 (ql3) pixels for the case where S3B had changed to a quality level of 3 (blue). In orange is the distance between ql5 and ql3 pixels when the S3B observation stayed at a quality level of 5 (no change) which can be considered the background distribution. This implies that 'proximity to cloud' (quality level 3 pixels) has an influence on the likelihood of a lower quality level being seen. The fact that some pixels change when the distance is large also implies that part of the time, a change in quality level is due to measurement uncertainty so there is also a real uncertainty related to the quality level value.

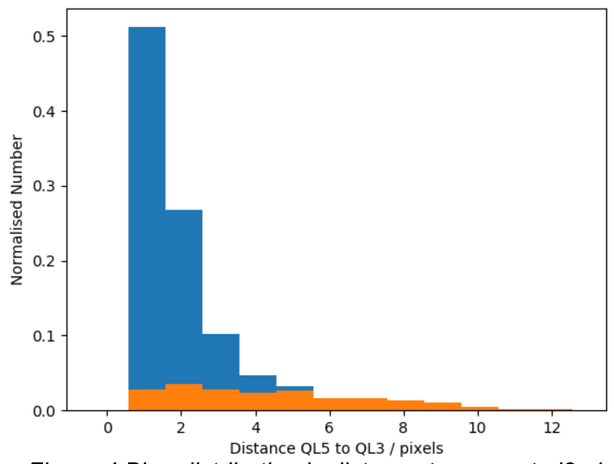

Figure 4 Blue distribution is distance to nearest ql3 pixel from a ql5 pixel in S3A data when S3B changed quality level to ql3. Orange is same distance when there was no change in quality level between S3A and S3B.

Bias and uncertainty as a function of cloud probability

Because the Tandem data allows two looks at the same location when the SST should not have changed significantly, changes in the observed SST can be related to other effects such as cloud. Figures 5 shows the SST difference as a function of P_{Cloud} /P_{Cloud} difference (zeroed to zero probability/probability difference) for quality level 5 data for each retrieval algorithm and show a cold bias with increasing cloud. Figure 5 also shows an increase in the SST difference standard deviation which is evidence for another missing uncertainty component related to cloud detection probability. Both the cloud related bias and uncertainty have not been previously estimated.

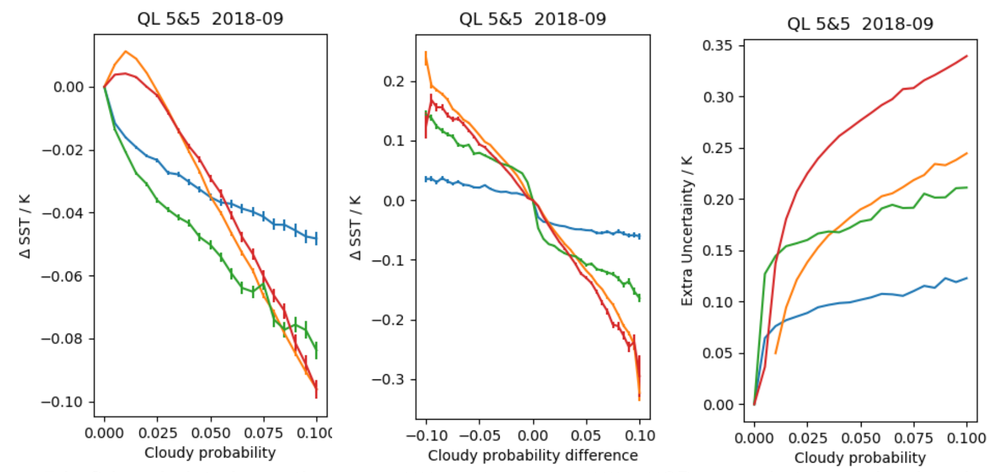

Figure 5 Left hand plot shows the mean SST differences (S3A-S3B zeroed at zero cloud probability) for different algorithms (N2-Blue, N3-Orange,D2-Green,D3-Red) as a function of P_{cloud}, Middle plot shows the SST difference as a function of P_{cloud} differences and the right hand plot shows the standard deviation of the SST differences as a function of cloud probability (uncertainty component).

CONCLUSIONS

The SLSTR Tandem phase data is extremely useful not only in showing how close the S3A and S3B versions are in behavior but also in finding small issues/problems. It has also highlighted new components of uncertainty including uncertainties related to quality level as well as uncertainties/variations in the quality level itself together with biases/uncertainties associated with P_{Cloud}. The Tandem phase data therefore provides a powerful new tool to better understand SST retrievals from the SLSTR instrument.