

INSAT-3D Sounder Cloud Mask Validation Report

Validation Criteria :

1. Spatial Collocation : 10km (nominal resolution of INSAT-3D Sounder)
2. Temporal Collocation : 5 minutes

INSAT-3D sounder operational cloud mask product is available at 10km resolution at nadir. MODIS cloud mask product is available at 1 km resolution at nadir. Hence there will be approximately 100 pixels of Modis inside one Sounder Pixels provided both are looking at nadir. In general, there is around 40-60 pixels of MODIS per sounder pixel.

Furthermore operational MODIS cloud mask has 4 flags : Confident clear, probably clear, probably cloudy and cloudy, while operational sounder cloud mask has only 3 flags : Clear, Cloudy and Uncertain. For validation we follow these steps :

1. Spatial and Temporal Collocation
2. Resampling of MODIS cloud Mask on sounder observation area
3. Conversion of 4 cloud flags of MODIS into 3 cloud flags of sounder

The following methodology is adopted for conversion of MODIS cloud flag to sounder cloud flag

(i) A probability value is assigned to each of the modis cloud flag. Here we have assigned the values of 0.125,0.25,0.5,1 for confident clear, probably clear, probably cloudy and cloudy respectively.

(ii) For each collocated sounder pixel , a single probability value for MODIS is obtained using the following 3 methods of averaging :

- a) Taking mode of modis pixel probability value
- b) Taking weighted average of probability values
- c) Taking weighted products of the odds and subtracting the final results from 1

(iii)Based on probability value (p) obtained from above mentioned methods, the cloud mask flag for modis is decided for each method as follows :

$p < 0.35$: Cloudy

$p = 0.35-0.75$: Uncertain

$p > 0.75$: Clear

Based on this flag , confusion matrix and skill scores were computed for each of the 3 methods.

The validation statistics are presented in following order :

1. All Surface
2. Land
3. Ocean
4. Coast
5. Highland (surface height > 2000 m)

For each of the 5 surface types , results are further categorised according to time of the day

1. All times
2. Daytime (0-12 UTC i.e. 05:30-17:30 IST)
3. Nighttime (12-24 UTC i.e. 17:30-05:30 IST)

For each of these cases following statistics are shown :

1. 3X3 Confusion matrices for clear, cloudy and uncertain conditions
2. Following skill scores based on confusion matrices :-
 - i). False Alarm Ratio (FAR)
 - ii). Frequency Bias (FB)
 - iii). Probability of Detection (POD)
 - iv). False Alarm Rate (F)
 - v). Proportion Correct (PCr)
 - vi). Kuiper Skill Score (KSS)
 - vii). Heidke Skill Score (HSS)

Following plots are also shown :

1. Time series of Total number of collocations obtained for each of the 5 categories
2. Time series of percentage correct pixels ($100 * PCr$)
3. Sample spatial plot of operational cloud products and collocations on Land and Ocean

INSAT-3D Sounder vs MODIS for April , 2017 (All times (day and night)) on all surface types

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 108747 | 63500 | 21443 |
| Sounder Uncertain | 10967 | 2541 | 7088 |
| Sounder Cloudy | 5271 | 3359 | 14943 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 100499 | 72695 | 20496 |
| Sounder Uncertain | 8755 | 5991 | 5850 |
| Sounder Cloudy | 4087 | 5427 | 14059 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 90768 | 79696 | 23226 |
| Sounder Uncertain | 7302 | 7003 | 6291 |
| Sounder Cloudy | 3380 | 5652 | 14541 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 45.72 | 26.70 | 9.02 |
| Sounder Uncertain | 4.61 | 1.07 | 2.98 |
| Sounder Cloudy | 2.22 | 1.41 | 6.28 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 42.25 | 30.56 | 8.62 |
| Sounder Uncertain | 3.68 | 2.52 | 2.46 |
| Sounder Cloudy | 1.72 | 2.28 | 5.91 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 38.16 | 33.51 | 9.76 |
| Sounder Uncertain | 3.07 | 2.94 | 2.64 |
| Sounder Cloudy | 1.42 | 2.38 | 6.11 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.44 | 0.88 | 0.37 |
| Frequency Bias | 1.55 | 0.30 | 0.54 |
| Probability of Detection | 0.87 | 0.04 | 0.34 |
| False Alarm Rate | 0.76 | 0.16 | 0.08 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.531 |
| Kuiper Skill Score | 0.098 |
| Heidke Skill Score | 0.112 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.48 | 0.71 | 0.40 |
| Frequency Bias | 1.71 | 0.24 | 0.58 |
| Probability of Detection | 0.89 | 0.07 | 0.35 |
| False Alarm Rate | 0.79 | 0.12 | 0.08 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.507 |
| Kuiper Skill Score | 0.115 |
| Heidke Skill Score | 0.126 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.53 | 0.66 | 0.38 |
| Frequency Bias | 1.91 | 0.22 | 0.54 |
| Probability of Detection | 0.89 | 0.08 | 0.33 |
| False Alarm Rate | 0.82 | 0.11 | 0.07 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.472 |
| Kuiper Skill Score | 0.115 |
| Heidke Skill Score | 0.121 |

INSAT-3D Sounder vs MODIS for April , 2017 (Day) on all surface types

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 57145 | 38833 | 15745 |
| Sounder Uncertain | 8267 | 1790 | 4122 |
| Sounder Cloudy | 4738 | 3108 | 10502 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 53767 | 41653 | 16303 |
| Sounder Uncertain | 6653 | 4226 | 3300 |
| Sounder Cloudy | 3729 | 4861 | 9758 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 46633 | 46749 | 18341 |
| Sounder Uncertain | 5398 | 5199 | 3582 |
| Sounder Cloudy | 3088 | 5080 | 10180 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 39.62 | 26.92 | 10.92 |
| Sounder Uncertain | 5.73 | 1.24 | 2.86 |
| Sounder Cloudy | 3.28 | 2.15 | 7.28 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 37.27 | 28.88 | 11.30 |
| Sounder Uncertain | 4.61 | 2.93 | 2.29 |
| Sounder Cloudy | 2.59 | 3.37 | 6.76 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 32.33 | 32.41 | 12.71 |
| Sounder Uncertain | 3.74 | 3.60 | 2.48 |
| Sounder Cloudy | 2.14 | 3.52 | 7.06 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.49 | 0.87 | 0.43 |
| Frequency Bias | 1.59 | 0.32 | 0.60 |
| Probability of Detection | 0.81 | 0.04 | 0.35 |
| False Alarm Rate | 0.73 | 0.17 | 0.10 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.481 |
| Kuiper Skill Score | 0.077 |
| Heidke Skill Score | 0.085 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.52 | 0.70 | 0.47 |
| Frequency Bias | 1.74 | 0.28 | 0.62 |
| Probability of Detection | 0.84 | 0.08 | 0.33 |
| False Alarm Rate | 0.76 | 0.13 | 0.11 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.470 |
| Kuiper Skill Score | 0.102 |
| Heidke Skill Score | 0.109 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.58 | 0.63 | 0.45 |
| Frequency Bias | 2.03 | 0.25 | 0.57 |
| Probability of Detection | 0.85 | 0.09 | 0.32 |
| False Alarm Rate | 0.79 | 0.11 | 0.10 |

Overall Skill Score

| Skill Score | Value |
|-------------|-------|
|-------------|-------|

| | |
|--------------------|-------|
| Proportion Correct | 0.430 |
| Kuiper Skill Score | 0.103 |
| Heidke Skill Score | 0.105 |

INSAT-3D Sounder vs MODIS for April , 2017 (Night) on all surface types

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 51602 | 24667 | 5698 |
| Sounder Uncertain | 2700 | 751 | 2966 |
| Sounder Cloudy | 533 | 251 | 4441 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 46732 | 31042 | 4193 |
| Sounder Uncertain | 2102 | 1765 | 2550 |
| Sounder Cloudy | 358 | 566 | 4301 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 44135 | 32947 | 4885 |
| Sounder Uncertain | 1904 | 1804 | 2709 |
| Sounder Cloudy | 292 | 572 | 4361 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 55.13 | 26.35 | 6.09 |
| Sounder Uncertain | 2.88 | 0.80 | 3.17 |
| Sounder Cloudy | 0.57 | 0.27 | 4.74 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 49.92 | 33.16 | 4.48 |
| Sounder Uncertain | 2.25 | 1.89 | 2.72 |
| Sounder Cloudy | 0.38 | 0.60 | 4.59 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 47.15 | 35.20 | 5.22 |
| Sounder Uncertain | 2.03 | 1.93 | 2.89 |
| Sounder Cloudy | 0.31 | 0.61 | 4.66 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.37 | 0.88 | 0.15 |
| Frequency Bias | 1.49 | 0.25 | 0.40 |
| Probability of Detection | 0.94 | 0.03 | 0.34 |
| False Alarm Rate | 0.82 | 0.15 | 0.02 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.607 |
| Kuiper Skill Score | 0.120 |
| Heidke Skill Score | 0.146 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------|-------|-----------|--------|
|-------------|-------|-----------|--------|

| | | | |
|--------------------------|------|------|------|
| False Alarm Ratio | 0.43 | 0.72 | 0.18 |
| Frequency Bias | 1.67 | 0.19 | 0.47 |
| Probability of Detection | 0.95 | 0.05 | 0.39 |
| False Alarm Rate | 0.86 | 0.11 | 0.02 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.564 |
| Kuiper Skill Score | 0.125 |
| Heidke Skill Score | 0.143 |

Method3: Taking Weighted Product average of MODIS pixels

| | | | |
|--------------------------|-------|-----------|--------|
| Skill Score | Clear | Uncertain | Cloudy |
| False Alarm Ratio | 0.46 | 0.72 | 0.17 |
| Frequency Bias | 1.77 | 0.18 | 0.44 |
| Probability of Detection | 0.95 | 0.05 | 0.36 |
| False Alarm Rate | 0.87 | 0.11 | 0.02 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.537 |
| Kuiper Skill Score | 0.119 |
| Heidke Skill Score | 0.133 |

INSAT-3D Sounder vs MODIS for April , 2017 (All times (day and night)) on Land

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| | | | |
|---------------|-------------|-----------------|--------------|
| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|

| | | | |
|-------------------|-------|------|------|
| Sounder Clear | 64764 | 7351 | 3715 |
| Sounder Uncertain | 7582 | 1363 | 2603 |
| Sounder Cloudy | 2990 | 1235 | 6599 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 62658 | 10585 | 2587 |
| Sounder Uncertain | 6213 | 3479 | 1856 |
| Sounder Cloudy | 2304 | 2560 | 5960 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 55567 | 17299 | 2964 |
| Sounder Uncertain | 5011 | 4489 | 2048 |
| Sounder Cloudy | 1800 | 2809 | 6215 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 65.95 | 7.49 | 3.78 |
| Sounder Uncertain | 7.72 | 1.39 | 2.65 |
| Sounder Cloudy | 3.04 | 1.26 | 6.72 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 63.81 | 10.78 | 2.63 |
| Sounder Uncertain | 6.33 | 3.54 | 1.89 |
| Sounder Cloudy | 2.35 | 2.61 | 6.07 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 56.58 | 17.62 | 3.02 |

| | | | |
|-------------------|------|------|------|
| Sounder Uncertain | 5.10 | 4.57 | 2.09 |
| Sounder Cloudy | 1.83 | 2.86 | 6.33 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.15 | 0.88 | 0.39 |
| Frequency Bias | 1.01 | 1.16 | 0.84 |
| Probability of Detection | 0.86 | 0.14 | 0.51 |
| False Alarm Rate | 0.43 | 0.40 | 0.17 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.741 |
| Kuiper Skill Score | 0.317 |
| Heidke Skill Score | 0.319 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.17 | 0.70 | 0.45 |
| Frequency Bias | 1.07 | 0.69 | 1.04 |
| Probability of Detection | 0.88 | 0.21 | 0.57 |
| False Alarm Rate | 0.50 | 0.31 | 0.19 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.734 |
| Kuiper Skill Score | 0.329 |
| Heidke Skill Score | 0.350 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------------|-------|-----------|--------|
| False Alarm Ratio | 0.27 | 0.61 | 0.43 |

| | | | |
|--------------------------|------|------|------|
| Frequency Bias | 1.22 | 0.47 | 0.96 |
| Probability of Detection | 0.89 | 0.18 | 0.55 |
| False Alarm Rate | 0.63 | 0.22 | 0.14 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.675 |
| Kuiper Skill Score | 0.273 |
| Heidke Skill Score | 0.304 |

INSAT-3D Sounder vs MODIS for April , 2017 (Day) on Land

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 38653 | 5274 | 2654 |
| Sounder Uncertain | 6491 | 979 | 1712 |
| Sounder Cloudy | 2782 | 1105 | 5165 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 36823 | 8066 | 1692 |
| Sounder Uncertain | 5193 | 2968 | 1021 |
| Sounder Cloudy | 2119 | 2381 | 4552 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 30955 | 13631 | 1995 |

| | | | |
|-------------------|------|------|------|
| Sounder Uncertain | 4088 | 3915 | 1179 |
| Sounder Cloudy | 1651 | 2616 | 4785 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 59.64 | 8.14 | 4.09 |
| Sounder Uncertain | 10.01 | 1.51 | 2.64 |
| Sounder Cloudy | 4.29 | 1.70 | 7.97 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 56.81 | 12.44 | 2.61 |
| Sounder Uncertain | 8.01 | 4.58 | 1.58 |
| Sounder Cloudy | 3.27 | 3.67 | 7.02 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 47.76 | 21.03 | 3.08 |
| Sounder Uncertain | 6.31 | 6.04 | 1.82 |
| Sounder Cloudy | 2.55 | 4.04 | 7.38 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.17 | 0.89 | 0.43 |
| Frequency Bias | 0.97 | 1.25 | 0.95 |
| Probability of Detection | 0.81 | 0.13 | 0.54 |
| False Alarm Rate | 0.40 | 0.41 | 0.19 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.691 |
| Kuiper Skill Score | 0.294 |
| Heidke Skill Score | 0.285 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.21 | 0.68 | 0.50 |
| Frequency Bias | 1.06 | 0.68 | 1.25 |
| Probability of Detection | 0.83 | 0.22 | 0.63 |
| False Alarm Rate | 0.48 | 0.30 | 0.22 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.684 |
| Kuiper Skill Score | 0.311 |
| Heidke Skill Score | 0.322 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.34 | 0.57 | 0.47 |
| Frequency Bias | 1.27 | 0.46 | 1.14 |
| Probability of Detection | 0.84 | 0.19 | 0.60 |
| False Alarm Rate | 0.62 | 0.21 | 0.17 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.612 |
| Kuiper Skill Score | 0.253 |
| Heidke Skill Score | 0.270 |

INSAT-3D Sounder vs MODIS for April , 2017 (Night) on Land

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 26111 | 2077 | 1061 |
| Sounder Uncertain | 1091 | 384 | 891 |
| Sounder Cloudy | 208 | 130 | 1434 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 25835 | 2519 | 895 |
| Sounder Uncertain | 1020 | 511 | 835 |
| Sounder Cloudy | 185 | 179 | 1408 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 24612 | 3668 | 969 |
| Sounder Uncertain | 923 | 574 | 869 |
| Sounder Cloudy | 149 | 193 | 1430 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 78.21 | 6.22 | 3.18 |
| Sounder Uncertain | 3.27 | 1.15 | 2.67 |
| Sounder Cloudy | 0.62 | 0.39 | 4.30 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 77.38 | 7.54 | 2.68 |
| Sounder Uncertain | 3.06 | 1.53 | 2.50 |
| Sounder Cloudy | 0.55 | 0.54 | 4.22 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 73.72 | 10.99 | 2.90 |
| Sounder Uncertain | 2.76 | 1.72 | 2.60 |
| Sounder Cloudy | 0.45 | 0.58 | 4.28 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.11 | 0.84 | 0.19 |
| Frequency Bias | 1.07 | 0.91 | 0.52 |
| Probability of Detection | 0.95 | 0.15 | 0.42 |
| False Alarm Rate | 0.57 | 0.36 | 0.06 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.837 |
| Kuiper Skill Score | 0.344 |
| Heidke Skill Score | 0.394 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.12 | 0.78 | 0.21 |
| Frequency Bias | 1.08 | 0.74 | 0.56 |
| Probability of Detection | 0.96 | 0.16 | 0.45 |
| False Alarm Rate | 0.61 | 0.33 | 0.06 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.831 |
| Kuiper Skill Score | 0.337 |
| Heidke Skill Score | 0.395 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.16 | 0.76 | 0.19 |
| Frequency Bias | 1.14 | 0.53 | 0.54 |
| Probability of Detection | 0.96 | 0.13 | 0.44 |
| False Alarm Rate | 0.68 | 0.26 | 0.05 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.797 |
| Kuiper Skill Score | 0.285 |
| Heidke Skill Score | 0.349 |

INSAT-3D Sounder vs MODIS for April , 2017 (All times (day and night)) on Ocean

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 40361 | 54972 | 16723 |
| Sounder Uncertain | 1818 | 981 | 3714 |
| Sounder Cloudy | 993 | 1879 | 5217 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 34659 | 60238 | 17159 |
| Sounder Uncertain | 1266 | 1839 | 3408 |
| Sounder Cloudy | 822 | 2022 | 5245 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 32393 | 60246 | 19417 |
| Sounder Uncertain | 1152 | 1753 | 3608 |
| Sounder Cloudy | 749 | 1947 | 5393 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 31.87 | 43.40 | 13.20 |
| Sounder Uncertain | 1.44 | 0.77 | 2.93 |
| Sounder Cloudy | 0.78 | 1.48 | 4.12 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 27.36 | 47.56 | 13.55 |
| Sounder Uncertain | 1.00 | 1.45 | 2.69 |
| Sounder Cloudy | 0.65 | 1.60 | 4.14 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 25.58 | 47.57 | 15.33 |
| Sounder Uncertain | 0.91 | 1.38 | 2.85 |
| Sounder Cloudy | 0.59 | 1.54 | 4.26 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.64 | 0.85 | 0.36 |
| Frequency Bias | 2.60 | 0.11 | 0.32 |
| Probability of Detection | 0.93 | 0.02 | 0.20 |
| False Alarm Rate | 0.90 | 0.07 | 0.04 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.368 |
| Kuiper Skill Score | 0.047 |
| Heidke Skill Score | 0.045 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.69 | 0.72 | 0.35 |
| Frequency Bias | 3.05 | 0.10 | 0.31 |
| Probability of Detection | 0.94 | 0.03 | 0.20 |
| False Alarm Rate | 0.91 | 0.06 | 0.03 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.330 |
| Kuiper Skill Score | 0.055 |
| Heidke Skill Score | 0.048 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.71 | 0.73 | 0.33 |
| Frequency Bias | 3.27 | 0.10 | 0.28 |
| Probability of Detection | 0.94 | 0.03 | 0.19 |
| False Alarm Rate | 0.91 | 0.05 | 0.03 |

Overall Skill Score

| Skill Score | Value |
|-------------|-------|
|-------------|-------|

| | |
|--------------------|-------|
| Proportion Correct | 0.312 |
| Kuiper Skill Score | 0.052 |
| Heidke Skill Score | 0.045 |

INSAT-3D Sounder vs MODIS for April , 2017 (Day) on Ocean

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 16430 | 33112 | 12448 |
| Sounder Uncertain | 415 | 679 | 1930 |
| Sounder Cloudy | 770 | 1763 | 3236 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 15099 | 32768 | 14123 |
| Sounder Uncertain | 337 | 739 | 1948 |
| Sounder Cloudy | 703 | 1728 | 3338 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 13990 | 32194 | 15806 |
| Sounder Uncertain | 301 | 687 | 2036 |
| Sounder Cloudy | 648 | 1661 | 3460 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 23.21 | 46.78 | 17.59 |
| Sounder Uncertain | 0.59 | 0.96 | 2.73 |
| Sounder Cloudy | 1.09 | 2.49 | 4.57 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 21.33 | 46.29 | 19.95 |
| Sounder Uncertain | 0.48 | 1.04 | 2.75 |
| Sounder Cloudy | 0.99 | 2.44 | 4.72 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 19.76 | 45.48 | 22.33 |
| Sounder Uncertain | 0.43 | 0.97 | 2.88 |
| Sounder Cloudy | 0.92 | 2.35 | 4.89 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.73 | 0.78 | 0.44 |
| Frequency Bias | 3.52 | 0.09 | 0.33 |
| Probability of Detection | 0.93 | 0.02 | 0.18 |
| False Alarm Rate | 0.90 | 0.05 | 0.05 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.287 |
| Kuiper Skill Score | 0.044 |
| Heidke Skill Score | 0.037 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------|-------|-----------|--------|
|-------------|-------|-----------|--------|

| | | | |
|--------------------------|------|------|------|
| False Alarm Ratio | 0.76 | 0.76 | 0.42 |
| Frequency Bias | 3.84 | 0.09 | 0.30 |
| Probability of Detection | 0.94 | 0.02 | 0.17 |
| False Alarm Rate | 0.91 | 0.04 | 0.05 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.271 |
| Kuiper Skill Score | 0.044 |
| Heidke Skill Score | 0.036 |

Method3: Taking Weighted Product average of MODIS pixels

| | | | |
|--------------------------|-------|-----------|--------|
| Skill Score | Clear | Uncertain | Cloudy |
| False Alarm Ratio | 0.77 | 0.77 | 0.40 |
| Frequency Bias | 4.15 | 0.09 | 0.27 |
| Probability of Detection | 0.94 | 0.02 | 0.16 |
| False Alarm Rate | 0.91 | 0.04 | 0.04 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.256 |
| Kuiper Skill Score | 0.042 |
| Heidke Skill Score | 0.034 |

INSAT-3D Sounder vs MODIS for April , 2017 (Night) on Ocean

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| | | | |
|---------------|-------------|-----------------|--------------|
| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|

| | | | |
|-------------------|-------|-------|------|
| Sounder Clear | 23931 | 21860 | 4275 |
| Sounder Uncertain | 1403 | 302 | 1784 |
| Sounder Cloudy | 223 | 116 | 1981 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 19560 | 27470 | 3036 |
| Sounder Uncertain | 929 | 1100 | 1460 |
| Sounder Cloudy | 119 | 294 | 1907 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 18403 | 28052 | 3611 |
| Sounder Uncertain | 851 | 1066 | 1572 |
| Sounder Cloudy | 101 | 286 | 1933 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 42.83 | 39.12 | 7.65 |
| Sounder Uncertain | 2.51 | 0.54 | 3.19 |
| Sounder Cloudy | 0.40 | 0.21 | 3.55 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 35.01 | 49.16 | 5.43 |
| Sounder Uncertain | 1.66 | 1.97 | 2.61 |
| Sounder Cloudy | 0.21 | 0.53 | 3.41 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 32.94 | 50.20 | 6.46 |

| | | | |
|-------------------|------|------|------|
| Sounder Uncertain | 1.52 | 1.91 | 2.81 |
| Sounder Cloudy | 0.18 | 0.51 | 3.46 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.52 | 0.91 | 0.15 |
| Frequency Bias | 1.96 | 0.16 | 0.29 |
| Probability of Detection | 0.94 | 0.01 | 0.25 |
| False Alarm Rate | 0.88 | 0.11 | 0.01 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.469 |
| Kuiper Skill Score | 0.047 |
| Heidke Skill Score | 0.051 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.61 | 0.68 | 0.18 |
| Frequency Bias | 2.43 | 0.12 | 0.36 |
| Probability of Detection | 0.95 | 0.04 | 0.30 |
| False Alarm Rate | 0.92 | 0.07 | 0.01 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.404 |
| Kuiper Skill Score | 0.062 |
| Heidke Skill Score | 0.058 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------------|-------|-----------|--------|
| False Alarm Ratio | 0.63 | 0.69 | 0.17 |

| | | | |
|--------------------------|------|------|------|
| Frequency Bias | 2.59 | 0.12 | 0.33 |
| Probability of Detection | 0.95 | 0.04 | 0.27 |
| False Alarm Rate | 0.92 | 0.07 | 0.01 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.383 |
| Kuiper Skill Score | 0.059 |
| Heidke Skill Score | 0.053 |

INSAT-3D Sounder vs MODIS for April , 2017 (All times (day and night)) on Coast

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 516 | 193 | 170 |
| Sounder Uncertain | 86 | 36 | 59 |
| Sounder Cloudy | 98 | 32 | 93 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 434 | 322 | 123 |
| Sounder Uncertain | 71 | 66 | 44 |
| Sounder Cloudy | 76 | 70 | 77 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 380 | 366 | 133 |

| | | | |
|-------------------|----|----|----|
| Sounder Uncertain | 59 | 72 | 50 |
| Sounder Cloudy | 64 | 77 | 82 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 40.22 | 15.04 | 13.25 |
| Sounder Uncertain | 6.70 | 2.81 | 4.60 |
| Sounder Cloudy | 7.64 | 2.49 | 7.25 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 33.83 | 25.10 | 9.59 |
| Sounder Uncertain | 5.53 | 5.14 | 3.43 |
| Sounder Cloudy | 5.92 | 5.46 | 6.00 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 29.62 | 28.53 | 10.37 |
| Sounder Uncertain | 4.60 | 5.61 | 3.90 |
| Sounder Cloudy | 4.99 | 6.00 | 6.39 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.41 | 0.80 | 0.58 |
| Frequency Bias | 1.26 | 0.69 | 0.69 |
| Probability of Detection | 0.74 | 0.14 | 0.29 |
| False Alarm Rate | 0.57 | 0.23 | 0.20 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.503 |
| Kuiper Skill Score | 0.095 |
| Heidke Skill Score | 0.102 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.51 | 0.64 | 0.65 |
| Frequency Bias | 1.51 | 0.40 | 0.91 |
| Probability of Detection | 0.75 | 0.14 | 0.32 |
| False Alarm Rate | 0.63 | 0.16 | 0.21 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.450 |
| Kuiper Skill Score | 0.089 |
| Heidke Skill Score | 0.092 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.57 | 0.60 | 0.63 |
| Frequency Bias | 1.75 | 0.35 | 0.84 |
| Probability of Detection | 0.76 | 0.14 | 0.31 |
| False Alarm Rate | 0.67 | 0.15 | 0.19 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.416 |
| Kuiper Skill Score | 0.086 |
| Heidke Skill Score | 0.086 |

INSAT-3D Sounder vs MODIS for April , 2017 (Day) on Coast

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 257 | 54 | 112 |
| Sounder Uncertain | 63 | 25 | 40 |
| Sounder Cloudy | 98 | 32 | 84 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 231 | 108 | 84 |
| Sounder Uncertain | 55 | 46 | 27 |
| Sounder Cloudy | 76 | 69 | 69 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 211 | 121 | 91 |
| Sounder Uncertain | 48 | 47 | 33 |
| Sounder Cloudy | 64 | 76 | 74 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 33.59 | 7.06 | 14.64 |
| Sounder Uncertain | 8.24 | 3.27 | 5.23 |
| Sounder Cloudy | 12.81 | 4.18 | 10.98 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 30.20 | 14.12 | 10.98 |
| Sounder Uncertain | 7.19 | 6.01 | 3.53 |
| Sounder Cloudy | 9.93 | 9.02 | 9.02 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 27.58 | 15.82 | 11.90 |
| Sounder Uncertain | 6.27 | 6.14 | 4.31 |
| Sounder Cloudy | 8.37 | 9.93 | 9.67 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.39 | 0.80 | 0.61 |
| Frequency Bias | 1.01 | 1.15 | 0.91 |
| Probability of Detection | 0.61 | 0.23 | 0.36 |
| False Alarm Rate | 0.42 | 0.26 | 0.33 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.478 |
| Kuiper Skill Score | 0.112 |
| Heidke Skill Score | 0.112 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.45 | 0.64 | 0.68 |
| Frequency Bias | 1.17 | 0.57 | 1.19 |
| Probability of Detection | 0.64 | 0.21 | 0.38 |
| False Alarm Rate | 0.46 | 0.20 | 0.35 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.452 |
| Kuiper Skill Score | 0.120 |
| Heidke Skill Score | 0.122 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.50 | 0.63 | 0.65 |
| Frequency Bias | 1.31 | 0.52 | 1.08 |
| Probability of Detection | 0.65 | 0.19 | 0.37 |
| False Alarm Rate | 0.49 | 0.19 | 0.32 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.434 |
| Kuiper Skill Score | 0.114 |
| Heidke Skill Score | 0.117 |

INSAT-3D Sounder vs MODIS for April , 2017 (Night) on Coast

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 259 | 139 | 58 |
| Sounder Uncertain | 23 | 11 | 19 |
| Sounder Cloudy | 0 | 0 | 9 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 203 | 214 | 39 |
| Sounder Uncertain | 16 | 20 | 17 |
| Sounder Cloudy | 0 | 1 | 8 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 169 | 245 | 42 |
| Sounder Uncertain | 11 | 25 | 17 |
| Sounder Cloudy | 0 | 1 | 8 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 50.00 | 26.83 | 11.20 |
| Sounder Uncertain | 4.44 | 2.12 | 3.67 |
| Sounder Cloudy | 0.00 | 0.00 | 1.74 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 39.19 | 41.31 | 7.53 |
| Sounder Uncertain | 3.09 | 3.86 | 3.28 |
| Sounder Cloudy | 0.00 | 0.19 | 1.54 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 32.63 | 47.30 | 8.11 |
| Sounder Uncertain | 2.12 | 4.83 | 3.28 |
| Sounder Cloudy | 0.00 | 0.19 | 1.54 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.43 | 0.79 | 0.00 |
| Frequency Bias | 1.62 | 0.35 | 0.10 |
| Probability of Detection | 0.92 | 0.07 | 0.10 |
| False Alarm Rate | 0.82 | 0.18 | 0.00 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.539 |
| Kuiper Skill Score | 0.045 |
| Heidke Skill Score | 0.055 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.55 | 0.62 | 0.11 |
| Frequency Bias | 2.08 | 0.23 | 0.14 |
| Probability of Detection | 0.93 | 0.09 | 0.12 |
| False Alarm Rate | 0.88 | 0.11 | 0.00 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.446 |
| Kuiper Skill Score | 0.042 |
| Heidke Skill Score | 0.044 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.63 | 0.53 | 0.11 |
| Frequency Bias | 2.53 | 0.20 | 0.13 |
| Probability of Detection | 0.94 | 0.09 | 0.12 |
| False Alarm Rate | 0.91 | 0.09 | 0.00 |

Overall Skill Score

| Skill Score | Value |
|-------------|-------|
|-------------|-------|

| | |
|--------------------|-------|
| Proportion Correct | 0.390 |
| Kuiper Skill Score | 0.048 |
| Heidke Skill Score | 0.044 |

INSAT-3D Sounder vs MODIS for April , 2017 (All times (day and night)) on Highland (>2000 m)

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 721 | 27 | 145 |
| Sounder Uncertain | 1130 | 41 | 429 |
| Sounder Cloudy | 739 | 45 | 2560 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 670 | 121 | 102 |
| Sounder Uncertain | 927 | 394 | 279 |
| Sounder Cloudy | 489 | 512 | 2343 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 648 | 131 | 114 |
| Sounder Uncertain | 853 | 440 | 307 |
| Sounder Cloudy | 403 | 536 | 2405 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 12.35 | 0.46 | 2.48 |
| Sounder Uncertain | 19.36 | 0.70 | 7.35 |
| Sounder Cloudy | 12.66 | 0.77 | 43.86 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 11.48 | 2.07 | 1.75 |
| Sounder Uncertain | 15.88 | 6.75 | 4.78 |
| Sounder Cloudy | 8.38 | 8.77 | 40.14 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 11.10 | 2.24 | 1.95 |
| Sounder Uncertain | 14.61 | 7.54 | 5.26 |
| Sounder Cloudy | 6.90 | 9.18 | 41.20 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.19 | 0.97 | 0.23 |
| Frequency Bias | 0.34 | 14.16 | 1.07 |
| Probability of Detection | 0.28 | 0.36 | 0.82 |
| False Alarm Rate | 0.07 | 0.62 | 0.31 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.569 |
| Kuiper Skill Score | 0.366 |
| Heidke Skill Score | 0.304 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------|-------|-----------|--------|
|-------------|-------|-----------|--------|

| | | | |
|--------------------------|------|------|------|
| False Alarm Ratio | 0.25 | 0.75 | 0.30 |
| Frequency Bias | 0.43 | 1.56 | 1.23 |
| Probability of Detection | 0.32 | 0.38 | 0.86 |
| False Alarm Rate | 0.09 | 0.50 | 0.41 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.584 |
| Kuiper Skill Score | 0.342 |
| Heidke Skill Score | 0.339 |

Method3: Taking Weighted Product average of MODIS pixels

| | | | |
|--------------------------|-------|-----------|--------|
| Skill Score | Clear | Uncertain | Cloudy |
| False Alarm Ratio | 0.27 | 0.72 | 0.28 |
| Frequency Bias | 0.47 | 1.45 | 1.18 |
| Probability of Detection | 0.34 | 0.40 | 0.85 |
| False Alarm Rate | 0.10 | 0.49 | 0.40 |

Overall Skill Score

| | |
|--------------------|-------|
| Skill Score | Value |
| Proportion Correct | 0.598 |
| Kuiper Skill Score | 0.352 |
| Heidke Skill Score | 0.353 |

INSAT-3D Sounder vs MODIS for April , 2017 (Day) on Highland (>2000 m)

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| | | | |
|---------------|-------------|-----------------|--------------|
| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|

| | | | |
|-------------------|------|----|------|
| Sounder Clear | 607 | 6 | 28 |
| Sounder Uncertain | 1018 | 19 | 268 |
| Sounder Cloudy | 639 | 41 | 1596 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 573 | 59 | 9 |
| Sounder Uncertain | 843 | 318 | 144 |
| Sounder Cloudy | 435 | 423 | 1418 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 556 | 71 | 14 |
| Sounder Uncertain | 777 | 364 | 164 |
| Sounder Cloudy | 361 | 447 | 1468 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 14.38 | 0.14 | 0.66 |
| Sounder Uncertain | 24.11 | 0.45 | 6.35 |
| Sounder Cloudy | 15.14 | 0.97 | 37.80 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 13.57 | 1.40 | 0.21 |
| Sounder Uncertain | 19.97 | 7.53 | 3.41 |
| Sounder Cloudy | 10.30 | 10.02 | 33.59 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 13.17 | 1.68 | 0.33 |

| | | | |
|-------------------|-------|-------|-------|
| Sounder Uncertain | 18.40 | 8.62 | 3.88 |
| Sounder Cloudy | 8.55 | 10.59 | 34.77 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.05 | 0.99 | 0.30 |
| Frequency Bias | 0.28 | 19.77 | 1.20 |
| Probability of Detection | 0.27 | 0.29 | 0.84 |
| False Alarm Rate | 0.02 | 0.64 | 0.34 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.526 |
| Kuiper Skill Score | 0.388 |
| Heidke Skill Score | 0.295 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.11 | 0.76 | 0.38 |
| Frequency Bias | 0.35 | 1.63 | 1.45 |
| Probability of Detection | 0.31 | 0.40 | 0.90 |
| False Alarm Rate | 0.04 | 0.52 | 0.45 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.547 |
| Kuiper Skill Score | 0.349 |
| Heidke Skill Score | 0.328 |

Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|-------------------|-------|-----------|--------|
| False Alarm Ratio | 0.13 | 0.72 | 0.36 |

| | | | |
|--------------------------|------|------|------|
| Frequency Bias | 0.38 | 1.48 | 1.38 |
| Probability of Detection | 0.33 | 0.41 | 0.89 |
| False Alarm Rate | 0.05 | 0.51 | 0.44 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.566 |
| Kuiper Skill Score | 0.357 |
| Heidke Skill Score | 0.346 |

INSAT-3D Sounder vs MODIS for April , 2017 (Night) on Highland (>2000 m)

1. Confusion matrix of Total number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 114 | 21 | 117 |
| Sounder Uncertain | 112 | 22 | 161 |
| Sounder Cloudy | 100 | 4 | 964 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 97 | 62 | 93 |
| Sounder Uncertain | 84 | 76 | 135 |
| Sounder Cloudy | 54 | 89 | 925 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|---------------|-------------|-----------------|--------------|
| Sounder Clear | 92 | 60 | 100 |

| | | | |
|-------------------|----|----|-----|
| Sounder Uncertain | 76 | 76 | 143 |
| Sounder Cloudy | 42 | 89 | 937 |

2. Confusion matrix of percentage number of collocations

Method1 :Taking Mode of MODIS Pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 7.06 | 1.30 | 7.24 |
| Sounder Uncertain | 6.93 | 1.36 | 9.97 |
| Sounder Cloudy | 6.19 | 0.25 | 59.69 |

Method2 :Taking Weighted Average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 6.01 | 3.84 | 5.76 |
| Sounder Uncertain | 5.20 | 4.71 | 8.36 |
| Sounder Cloudy | 3.34 | 5.51 | 57.28 |

Method3: Taking Weighted Product average of MODIS pixels

| MODIS/Sounder | MODIS Clear | MODIS Uncertain | MODIS Cloudy |
|-------------------|-------------|-----------------|--------------|
| Sounder Clear | 5.70 | 3.72 | 6.19 |
| Sounder Uncertain | 4.71 | 4.71 | 8.85 |
| Sounder Cloudy | 2.60 | 5.51 | 58.02 |

3. Skill Scores

Method1 :Taking Mode of MODIS Pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.55 | 0.93 | 0.10 |
| Frequency Bias | 0.77 | 6.28 | 0.86 |
| Probability of Detection | 0.35 | 0.47 | 0.78 |
| False Alarm Rate | 0.27 | 0.53 | 0.20 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.681 |
| Kuiper Skill Score | 0.370 |
| Heidke Skill Score | 0.299 |

Method2 :Taking Weighted Average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.62 | 0.74 | 0.13 |
| Frequency Bias | 1.07 | 1.30 | 0.93 |
| Probability of Detection | 0.41 | 0.33 | 0.80 |
| False Alarm Rate | 0.30 | 0.42 | 0.28 |

Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.680 |
| Kuiper Skill Score | 0.355 |
| Heidke Skill Score | 0.332 |

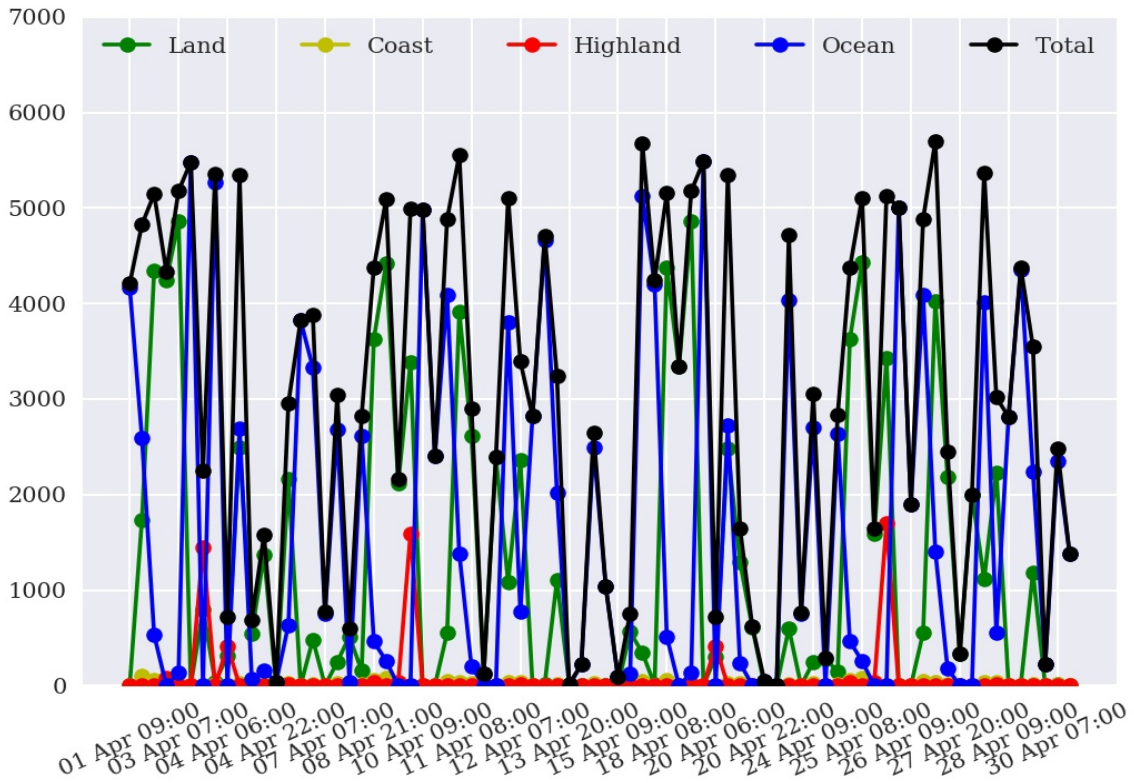
Method3: Taking Weighted Product average of MODIS pixels

| Skill Score | Clear | Uncertain | Cloudy |
|--------------------------|-------|-----------|--------|
| False Alarm Ratio | 0.63 | 0.74 | 0.12 |
| Frequency Bias | 1.20 | 1.31 | 0.91 |
| Probability of Detection | 0.44 | 0.34 | 0.79 |
| False Alarm Rate | 0.31 | 0.43 | 0.26 |

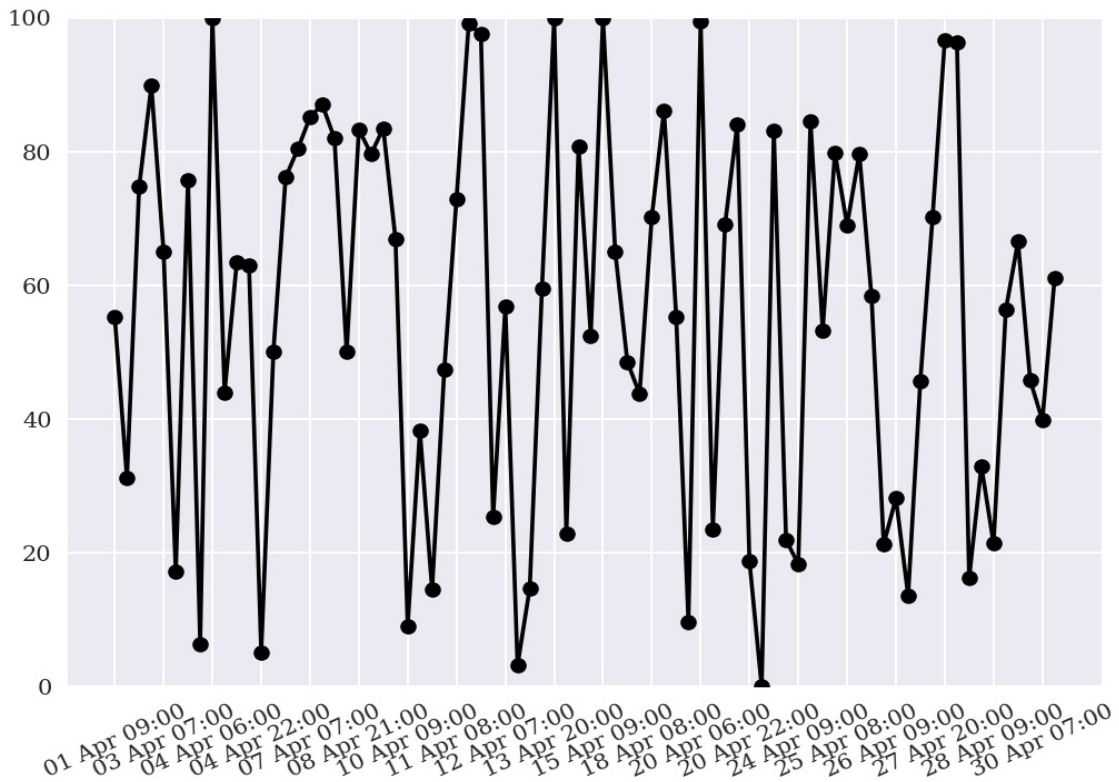
Overall Skill Score

| Skill Score | Value |
|--------------------|-------|
| Proportion Correct | 0.684 |
| Kuiper Skill Score | 0.361 |
| Heidke Skill Score | 0.330 |

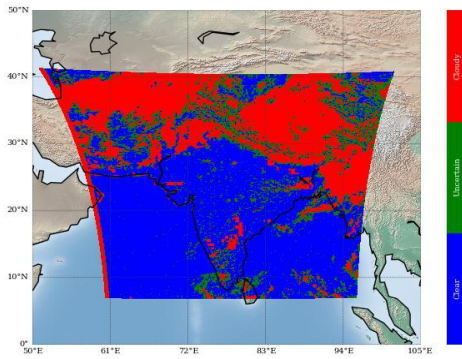
Number of Collocations for Apr-2017



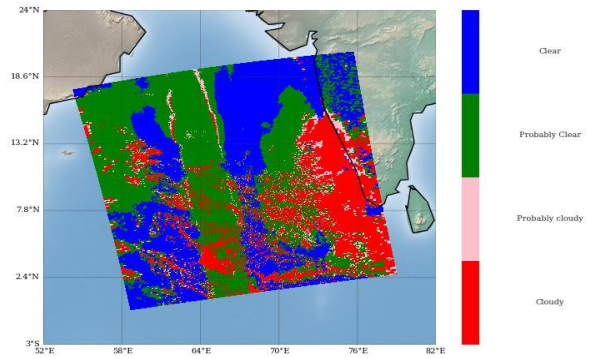
Percentage Correct for Apr-2017



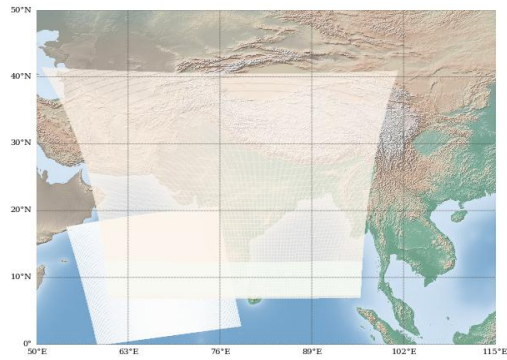
INSAT-3D Sounder Cloud Mask on 03 April, 2017 09:00 UTC



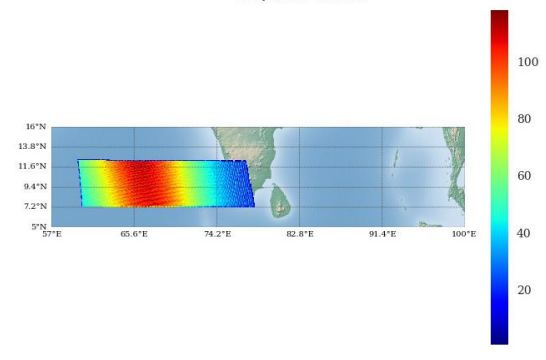
Modis Cloud Mask on 03 April, 2017 09:00 UTC



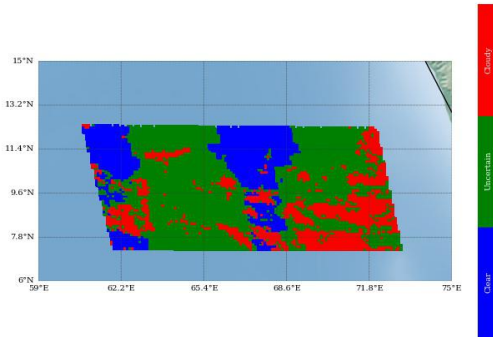
MODIS pass over INSAT-3D Sounder on 03 April, 2017 09:00 UTC



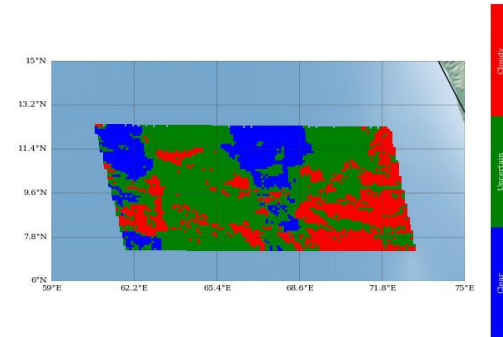
Number of Modis Pixels per Sounder Pixels on a spatially and Temporally Collocated Domain on 03 April, 2017 09:00 UTC



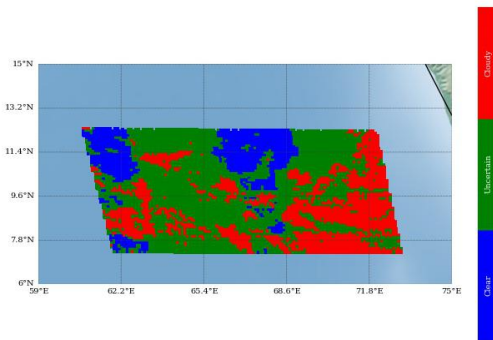
Modis Cloud Mask on Sounder Grid Method 1 : Mode of Modis pixels



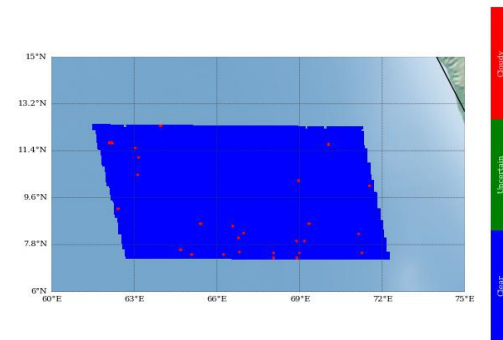
Modis Cloud Mask on Sounder Grid Method 2 : Weighted Average



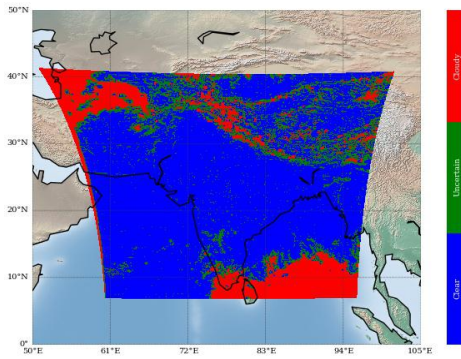
Modis Cloud Mask on Sounder Grid Method 3 : Weighted Product Average



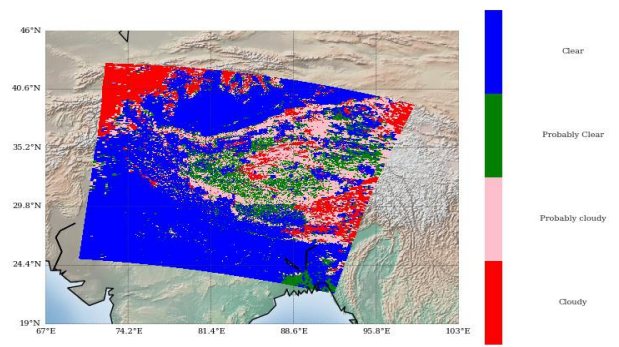
Sounder Cloud Flag on Collocated Area



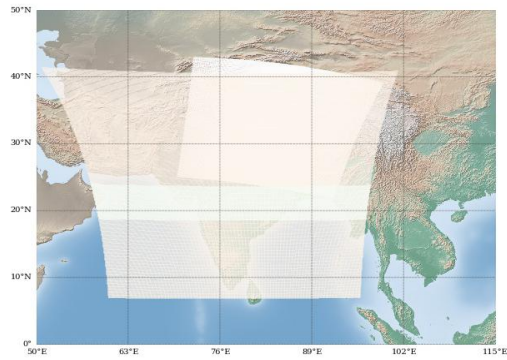
INSAT-3D Sounder Cloud Mask on 11 April, 2017 20:00 UTC



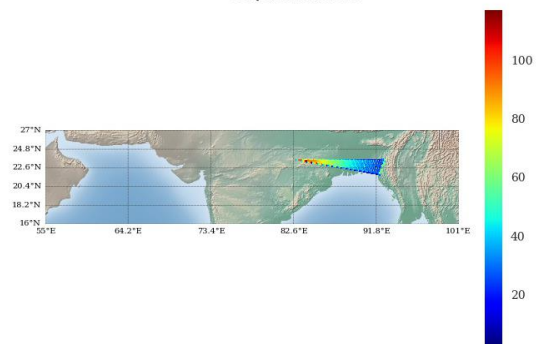
Modis Cloud Mask on 11 April, 2017 20:20 UTC



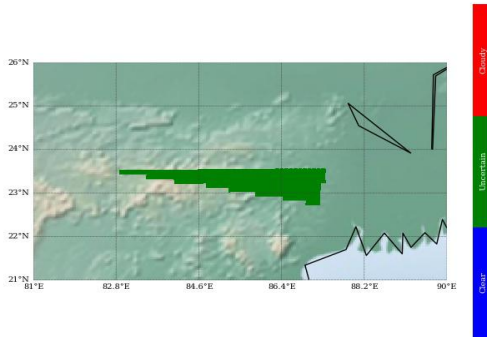
MODIS pass over INSAT-3D Sounder on 11 April, 2017 20:20 UTC



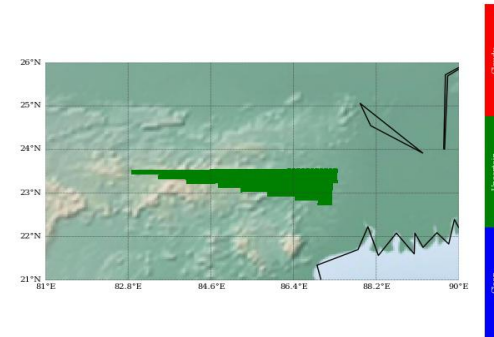
Number of Modis Pixels per Sounder Pixels on a spatially and Temporally Collocated Domain on 11 April, 2017 20:20 UTC



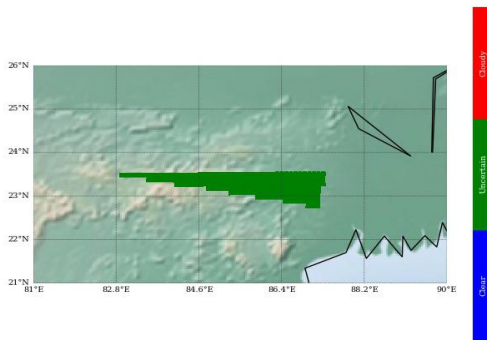
Modis Cloud Mask on Sounder Grid Method 1 : Mode of Modis pixels



Modis Cloud Mask on Sounder Grid Method 2 : Weighted Average



Modis Cloud Mask on Sounder Grid Method 3 : Weighted Product Average



Sounder Cloud Flag on Collocated Area

