# Quantifying the Impact of Spatial and Temporal Atmospheric Variability on GSICS Inter-Calibration algorithms

## or How Close is "Close Enough"?

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# The Problem

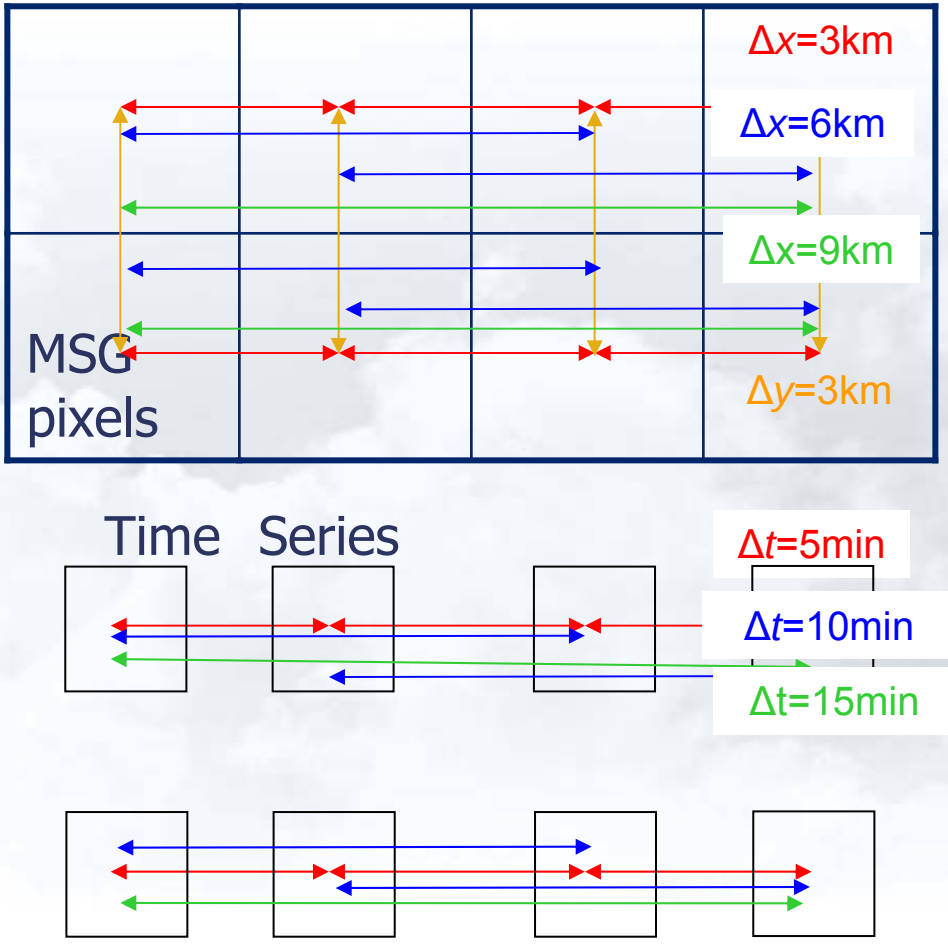
- Quantifying the Impact of Spatial and Temporal Atmospheric Variability on GSICS Inter-Calibration algorithms
  - Contribution to error budget
- Specifying collocation criteria
  - or How Close is “Close Enough”?

# The Method

- Calculate RMS Differences
  - in radiances
  - or brightness temperatures
- From GEO images

- Between all pixels within an image
  - separated by Δx in E/W direction
  - separated by Δy in N/S direction
  - $RMSDx=\langle[T_b(x+\Delta x)-T_b(x)]^2\rangle^{1/2}$

- Between pixels in series of images
  - separated by Δt in time series
  - $RMSDt=\langle[T_b(t+\Delta t)-T_b(t)]^2\rangle^{1/2}$



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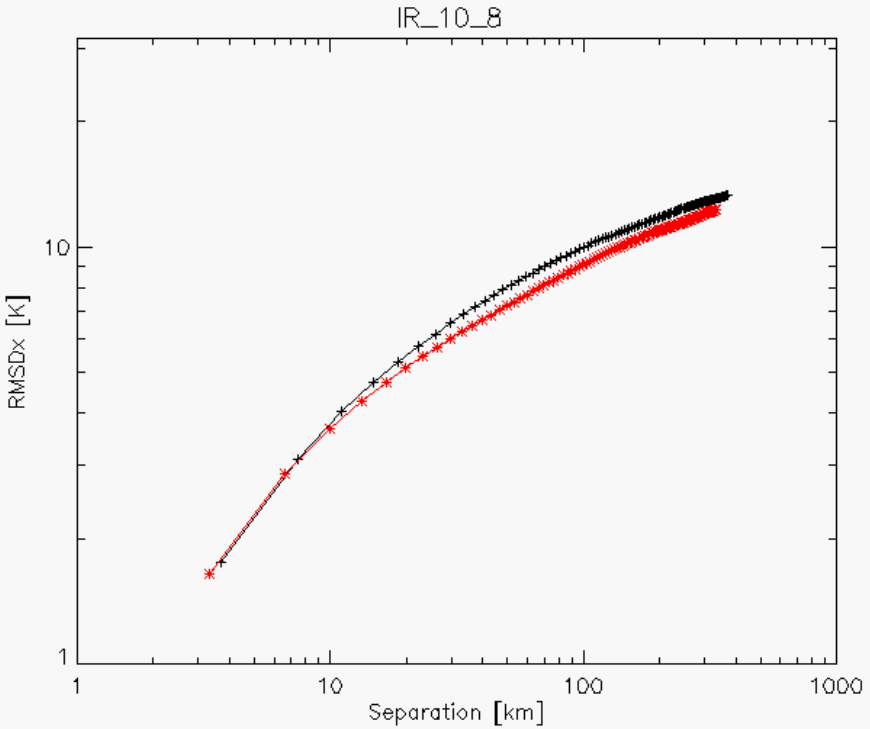
# Spatial Variability Results

- From single MSG image
  - 01:00 on 1 Feb 2006
  - (night-time)
  - But, Spatial Variability Varies!

- $RMSDx = \langle [T_b(x+\Delta x) - T_b(x)]^2 \rangle^{1/2}$
- Calculated for each IR Channel

- Limited to ±30°N/S ±30°E/W
  - GEO/LEO collocation domain
  - Pixel spacing ~uniform

- More variability in N/S than E/W
  - latitudinal temperature gradient
  - Difference negligible for Δx <~10 km




**R.M.S. Differences in Meteosat-8 10.8 µm brightness temperatures with spatial separation in North-South direction (black) and West-East direction (red).**



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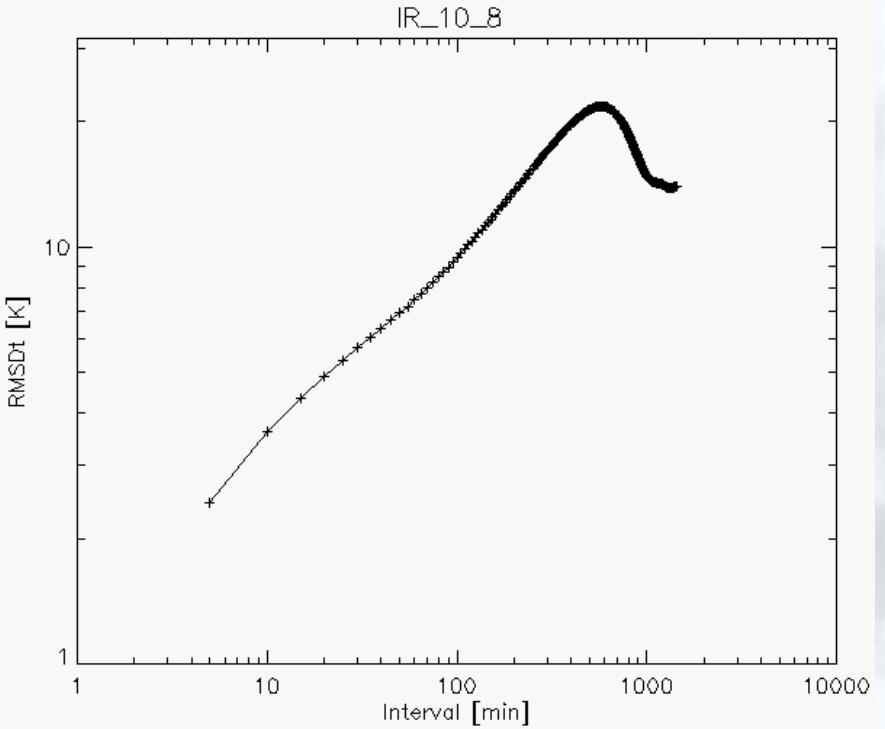
# Temporal Variability Results

- From 24hrs of rapid scan MSG data
  - 5 min sampling 18 April 2008
  - 15°N 30°W-30°E, 45°N 45°W-45°E
- Similar results from other case
  - 15 min sampling on 4 Feb 2006
  - Subset of full disc: ±30°N/S ±30°E/W
  - But, Temporal Variability Varies!

- $RMSDt = \langle [T_b(t+\Delta t) - T_b(t)]^2 \rangle^{1/2}$
- Calculated for each IR Channel

- Maximum variability for Δt ~12 hr
  - for all channels
  - but most in window channels
  - Diurnal cycle dominates variability on time scales longer than ~1 hr
  - causing $RMSD_t$ to increase more rapidly for increasing time intervals




**R.M.S. Differences in Meteosat-8 10.8 μm brightness temperatures with time intervals from Rapid Scanning Meteosat data**



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# Results for other channels

- Calculated for 8 IR channels of MSG
  - *RMSDt*($\Delta t$=15min)
  - *RMSDx*($\Delta x$=10km)
  - ≈ *RMSDy*($\Delta y$=10km)
- Window channels most variable
- *RMSD* >> Instrument noise
- Variability is comparable on these space and time scales
  - So omitting spatial variability will cause uncertainty on collocation to be underestimated by ~√2

**Table 1:** Temporal and Spatial Variability of Meteosat brightness temperatures on scales of 15 min and 10 km, respectively.

| Channel [μm] | $RMSD_t$($\Delta t$=15min) [K] | $RMSD_x$($\Delta x$=10km) [K] |
|---|---|---|
| 3.9 | 3.0 | 2.5 |
| 6.2 | 0.8 | 1.2 |
| 7.3 | 1.7 | 2.2 |
| 8.7 | 3.2 | 4.0 |
| 9.7 | 1.9 | 3.0 |
| 10.8 | 3.5 | 4.0 |
| 12.0 | 3.6 | 4.0 |
| 13.4 | 2.5 | 3.0 |

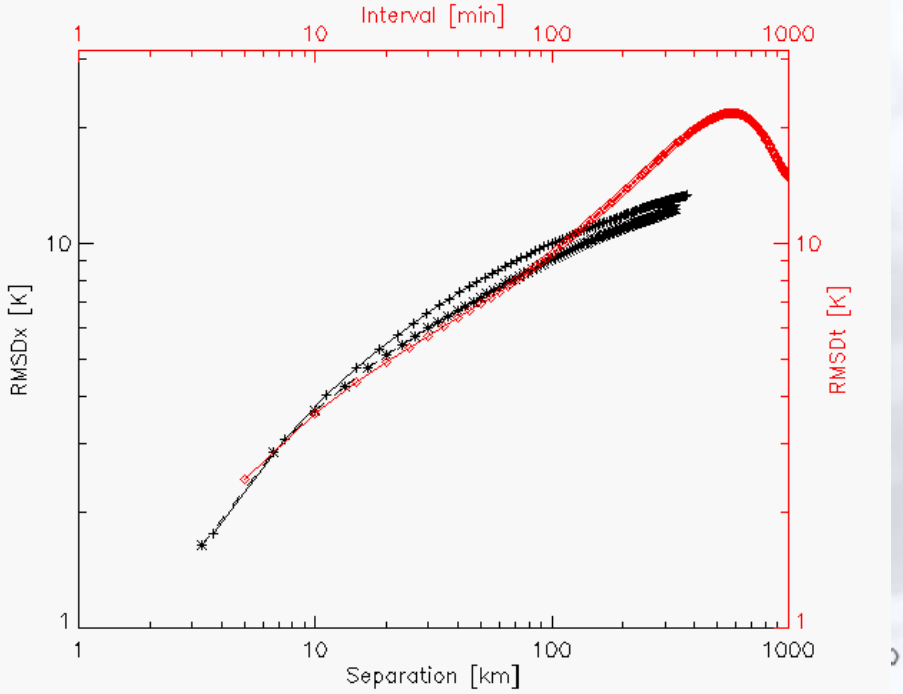
# Combining Spatial and Temporal Variability

- Spatial and temporal variability comparable on scales of:
  - 3 – 25 km (in N/S)
  - 5 – 45 min

- $RMSDt(\Delta t=15\text{min}) \approx RMSDy(\Delta y=10\text{km})$

- Suggest mesoscale features typically evolve at ~13 m/s
  - faster than advection (in tropics)

- Spatial and temporal collocation criteria are not independent!

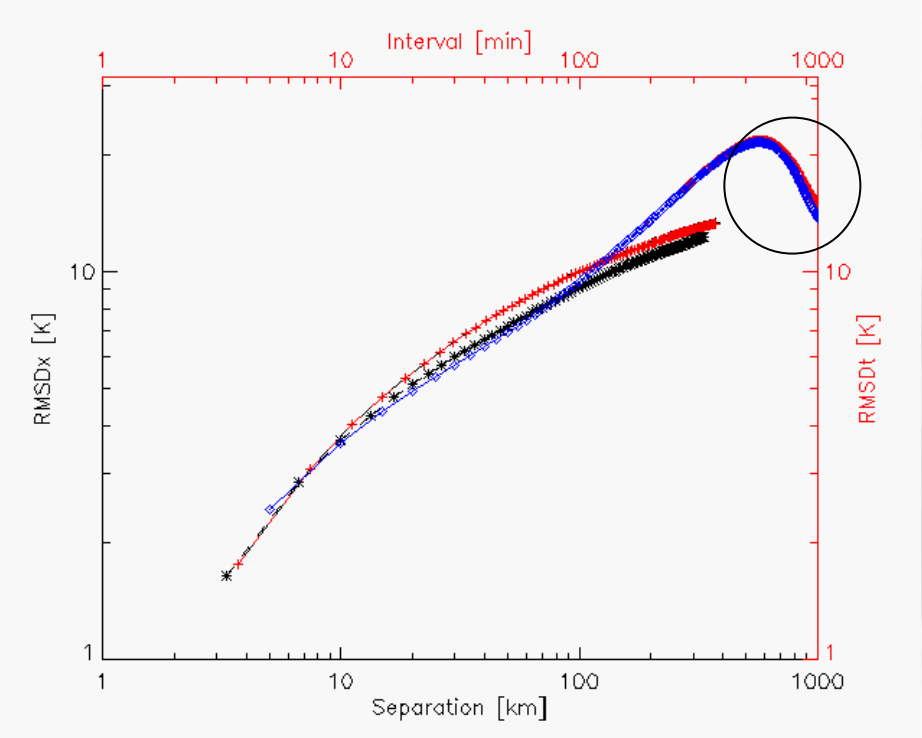



**R.M.S. Differences in Meteosat-8 10.8μm brightness temperatures with time intervals from Rapid Scanning Meteosat data (red) and spatial separation in N-S direction (black pluses) and W-E direction (black stars).**

# Impact of Mean Difference on *RMSD*

- *RMSD* statistics include any *systematic differences* in radiance differences

- Compare with Standard Deviation
  - Equivalent to subtracting mean difference before calculating *RMSD*
- But, mean differences tend to cancel
  - over large domain ~global
  - over long time series
- No differences in *RMSDx or RMSDy*
- 3% difference in *RMSDt*($\Delta t$ >12hr)
  - But test period only 24hr
  - Difference →0 for longer test periods?




**R.M.S. Differences in Meteosat-8 10.8 μm brightness temperatures with time intervals from Rapid Scanning Meteosat data**



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# Impact of Homogeneity Filtering

- Apply homogeneity filter by excluding 'noisy' pixels
  - SD of radiances within 5x5 pixels are >5% of the mean radiance
- Need to account for missing data when calculating *RMSD*

- *RMSDt* drops by a factor of 2.0
- *RMSDx* reduces by a factor of 2.6

- On very small scales or for homogeneous scenes
  - atmospheric variability << instrument's radiometric noise
  - *RMSD* will become constant with time and space (white noise)

# Conclusions

- Q: “What should collocation thresholds be in time and space?”
- A: “It depends”!

- It depends on how much noise is acceptable to introduce into each collocation due to atmospheric variability

- e.g. These results suggest thresholds of 15 min and 10 km would each introduce errors of 1-4 K into each collocation

- May be reduced to insignificant levels if many hundreds of collocations are combined in the analysis

# Thank you

Questions and Answers