Spurious Precipitation in TMI Retrievals within Marine Stratus

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Introduction and Motivation

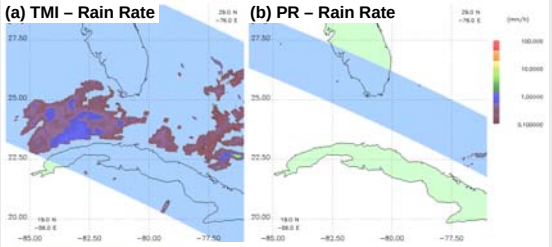
TMI indicates widespread areas of surface precipitation over the ocean that are, in fact, not precipitating. This spurious precipitation represents a source of error in TMI rainfall estimates. Identifying, characterizing, and explaining these areas of spurious precipitation is necessary for the TRMM data validation and error characterization process and is an essential mission goal.

This study characterizes and analyzes the distribution of TMI spurious precipitation, and poses a hypothesis based on cloud thickness for its mischaracterization in TMI products.

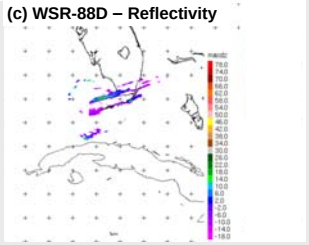
Physical Description and Characteristics

Observations from TRMM and GOES satellites, upper-air soundings, and coastal S-band radar indicate that TMI spurious precipitation:

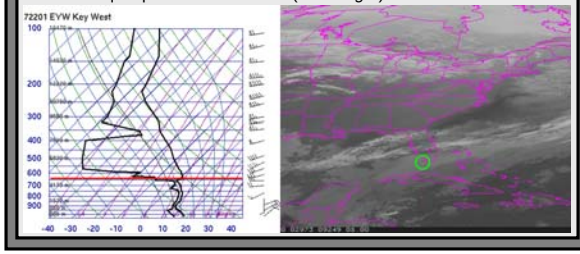
- Does not appear in either PR or more sensitive coastal radar
- Occurs in stratus clouds under a stable layer
- Has TMI rain rates up to 2.3 mm/hr, mean rain rate varies with case (0.6-1.2 mm/hr)
- Occurs within 3-4.5 km thick clouds with a liquid water path (LWP) from 0.5-1.2 kg/m^2 and a liquid water content (LWC) from 0.1-0.4 g/m^3



TMI spurious precipitation off the coast of Florida from 5 March 2002. The TMI (a) shows a widespread area of precipitation that does not appear in the corresponding PR (b) observations. The Key West and Miami coast WSR-88D (c) radars show some surface clutter, but do not the show the widespread area of precipitation indicated by TMI.



Upper-air soundings indicate that areas of spurious TMI precipitation have a cloud base close to the surface and a cloud top just below the freezing level (*below left, cloud top indicated by red line*). IR satellite indicates liquid-phase stratus cloud (*below right*).



TMI Spurious Precipitation Filter

Radiative Characteristics

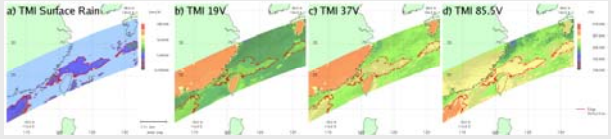
19V	195-225K
37V	230-254K
85.5V	267-280K

Surface Rain Rate Characteristics

0 mm/hr < R < 3 mm/hr

Surface Characteristics

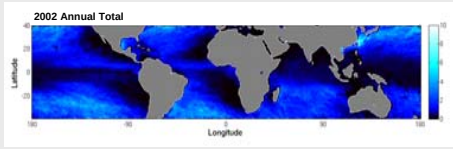
Ocean pixels only



An example of TMI spurious precipitation identified with the filter characteristics (left). Data are from the East China Sea on 1 Feb 2000. The region inside the red boundaries is spurious precipitation.

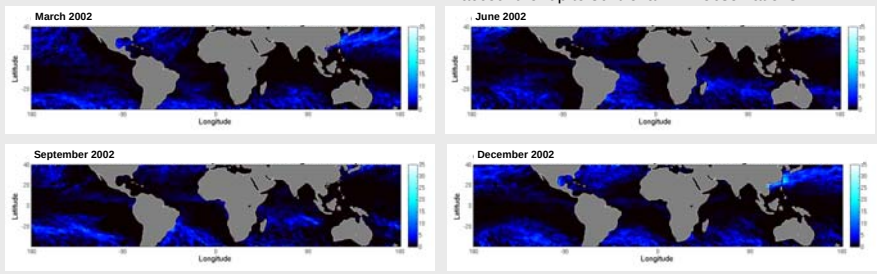
Frequency and Distribution of TMI Spurious Precipitation

Percentage of Observations with TMI Spurious Precipitation Signature

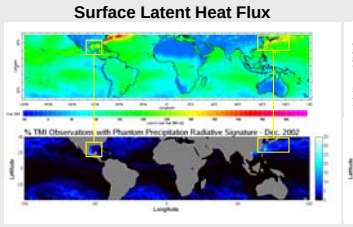


TMI spurious precipitation is most common in the winter season in the lee of continents at latitudes >15º. High frequencies of spurious precipitation occur in the East China Sea, US Atlantic Coast, and western Gulf of Mexico

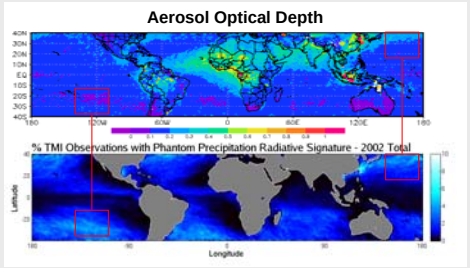
Spurious precipitation has a global annual frequency of 1% but can be as high as 10% regionally. On a monthly time scale over small areas, spurious precipitation can account for up to 30% of all TMI observations.



Correlation to Environmental Parameters



TMI spurious precipitation is weakly correlated with **surface latent heat flux** (*left*), and **liquid-phase optical thickness** (*right*). This suggests that spurious precipitation is related to moisture rich clouds with a low LCL.



The following parameters were found to have no significant correlation to TMI spurious precipitation.

Aerosol Optical Depth	Omega-500 mb
Mean Sea Level Pressure	MSLP Anomaly
Cloud Top Temperature	OLR
Effective Radius (liquid phase, ice phase and mixed phase)	Optical Thickness (ice phase and mixed phase)

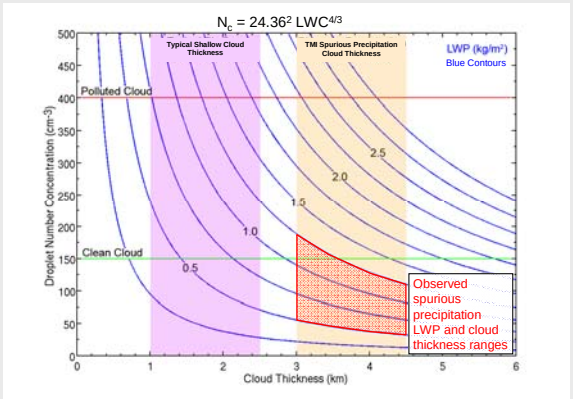
Liquid Water Path, Cloud Thickness, and Rain

Sounding data indicates that TMI spurious precipitation clouds are thicker than typical shallow marine clouds. For the same LWP, a thicker cloud will have a lower LWC since the moisture is spread over a broader layer and will be less likely to rain as a result. Since the TMI rain/no-rain threshold is based on LWP, the resulting cloud would have a LWP value that would indicate rain to the TMI algorithm but not have a LWC sufficient to support rain.

Critical droplet concentration value for autoconversion developed by Liu and Daum (2004): $N_c = 24.36^2\ LWC^{4/3}$

N_c = critical number concentration; LWC = liquid water content

Cloud-to-rain drop autoconversion (transition of cloud drops to rain drops) occurs when $N<N_c$. Rain forms when cloud drops are of sufficient size and number for collision-coalescence growth processes to be effective. Typical number concentrations (N) for clean and polluted clouds are shown below.



Conclusions

TMI spurious precipitation over ocean:

- **Occurs in thick liquid-phase stratus clouds where the LWC is not high enough to support the formation of rain droplets**
- **High LWP and low LWC can account for TMI rainfall false positive**
- **Occurs in high and low aerosol environments**
  - Aerosol Optical Depth does not correlate with TMI spurious precipitation
  - Aerosol indirect effect may contribute but does not dominate
- **Most common in winter season in lee of continents for latitudes >15º**
  - East China Sea, US Atlantic Coast, western Gulf of Mexico
- **Annual Frequency: 1% globally, up to 10% regionally**
  - Can account for 30% of observations at peak occurrence

Implications:

- **Positive bias in TMI and multi-sensor global estimates of precipitation over ocean (e.g. GPCP)**

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