P4.13 A TRMM-CALIBRATED INFRARED TECHNIQUE FOR GLOBAL RAINFALL ESTIMATION

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1. INTRODUCTION

This paper presents the development of a satellite infrared (IR) technique for estimating convective and stratiform rainfall and its application in studying the diurnal variability of rainfall on a global scale. The Convective-Stratiform Technique (CST), calibrated by coincident, physically retrieved rain rates from the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR), is applied over the global tropics during summer 2001. The technique is calibrated separately over land and ocean, making ingenious use of the IR data from the TRMM Visible/Infrared Scanner (VIRS) before application to global geosynchronous satellite data. The low sampling rate of TRMM PR imposes limitations on calibrating IR-based techniques; however, our research shows that PR observations can be applied to improve IR-based techniques significantly by selecting adequate calibration areas and calibration length. The diurnal cycle of rainfall, as well as the division between convective and stratiform rainfall will be presented. The technique is validated using available data sets and compared to other global rainfall products such as Global Precipitation Climatology Project (GPCP) IR product, calibrated with TRMM Microwave Imager (TMI) data. The calibrated CST technique has the advantages of high spatial resolution (4 km), filtering of non-raining cirrus clouds, and the stratification of the rainfall into its convective and stratiform components, the latter being important for the calculation of vertical profiles of latent heating.

The Convective-Stratiform Technique (CST) was designed to estimate precipitation of the scale of individual thunderstorms. The original application (Adler and Negri, 1988) was over southern Florida, and the technique was calibrated by the output from a 1-D model. With the launch of the Tropical Rainfall Measuring Mission (TRMM) in November 1997, high quality, high-resolution, instantaneous microwave-based estimates became available from the (passive) TRMM Microwave Radiometer (TMI) and the (active) TRMM Precipitation Radar (PR). Negri et al (2002) used TMI derived rain rates to recalibrate the CST over northern South America. One result is shown in Figure 1, the arithmetic difference between CST/TMI estimates at 18 local time (LT) and 06 LT for the period Jan.-Apr. 1999. Afternoon maxima appear as yellow to red shades, morning maxima in the dark blue shades. While most of the land areas display afternoon maxima, there are significant morning maxima, such as the region along the Amazon River east of Manaus. These tend to be the result of local circulation (land/sea, river breeze, mountain/valley) and exert import local controls of the diurnal cycle of rainfall. Other morning maxima can be found at the mouth of the Amazon at Belem and in the Gulf of Panama, offshore of Columbia.

Validation of these diurnal estimates was possible during the Large-Scale Biosphere-Atmosphere (LBA) experiment, conducted in Rondonia (southwest Brazil) in early 1999. Figure 2 shows the diurnal cycle estimates by two satellite-based techniques, the CST/TMI and the GOES Precipitation Index (GPI). Both are compared to estimates from the *in situ* NCAR TOGA radar. The GPI, threshold technique tends to lag the radar by 3 h. In contrast, the CST/TMI produces only a 1 h time lag. The CST also divides the estimated precipitation into its convective and stratiform components (Figure 2, bottom).

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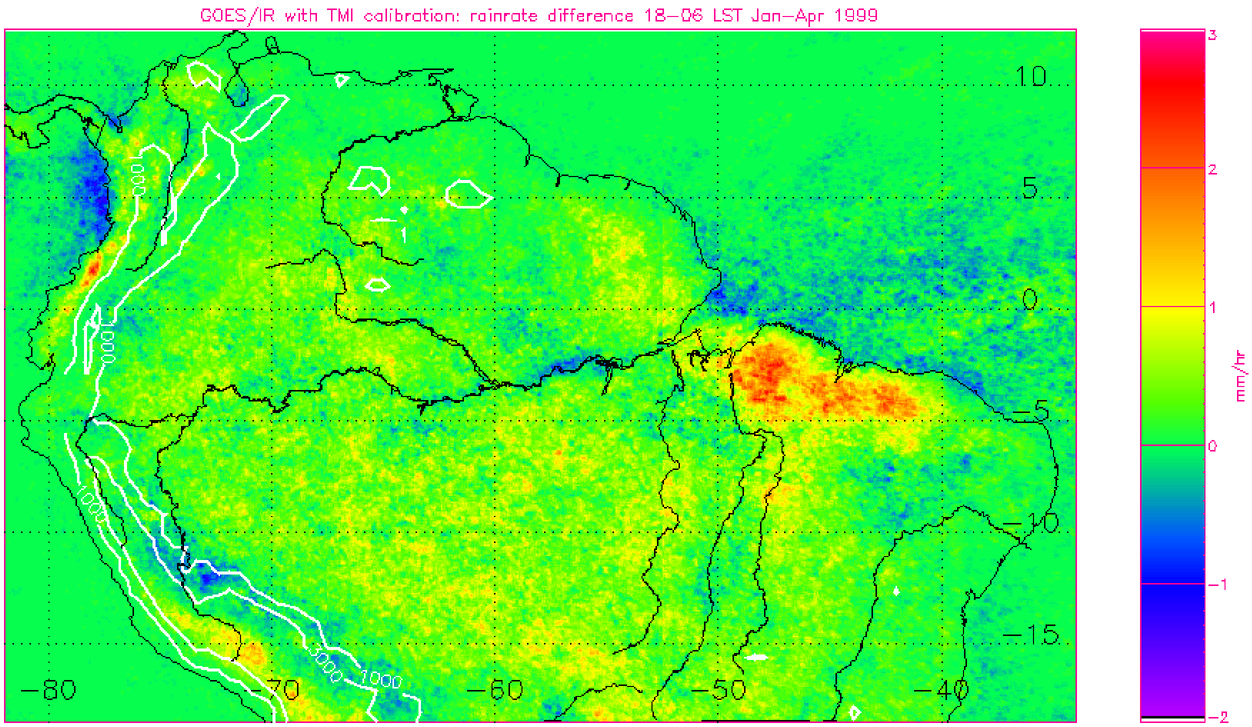

Figure 1: Application of the CST/TMI to the period Jan.- Apr. 1999, Shown is the difference (mm/h) between rain rate estimates at 18 LT and 06 LT. The 1000m and 3000m height contours are overlain.

2. RESULTS

In his study we present work-in-progress to recalibrate the CST globally using instantaneous estimates from the TRMM PR. As an intermediate step, we utilize IR data from the TRMM Visible and Infrared Scanner (VIRS), which has collocated IR and radar data along the rather narrow radar swath. We then apply this calibration to global IR data produced by NOAA/NCEP (Janowiak et al, 2001). Figure 3 shows an example of the PR and VIRS orbits for one day, along with one half-hour image of global IR for that day. The resolution of all the data sets is 4 km. We calibrate the CST/PR separately over land and ocean, by assigning a probability of precipitation to each IR minimum in temperature. Figure 4 illustrates this process. The 2-dimensional gradient around each minimum is also a parameter in this model.

Results for the 3-month period June-August (JJA) 2001 are shown in Figure 5. The major precipitation features are apparent: the narrow ITCZ and the intense rainfall over the Maritime Continent. The percentage of convective rain was about 50% over the oceans and about 60% over tropical land areas. For comparison, rain rates estimated from the TRMM product 3B43 are shown in Figure 6. The two estimates are in good qualitative agreement, however a more rigorous comparison needs to be undertaken.

Figure 7 (top) shows the CST/PR estimates of the diurnal cycle of precipitation for a large oceanic area in the western Pacific (left) and for the Amazon Basin (right) for JJA 2001. These are compared to the PR estimates alone, using the 4-year period Jan. 1998 to Dec. 2002.to generate sufficient sampling, Agreement is quite good particularly over the Amazon Basin.

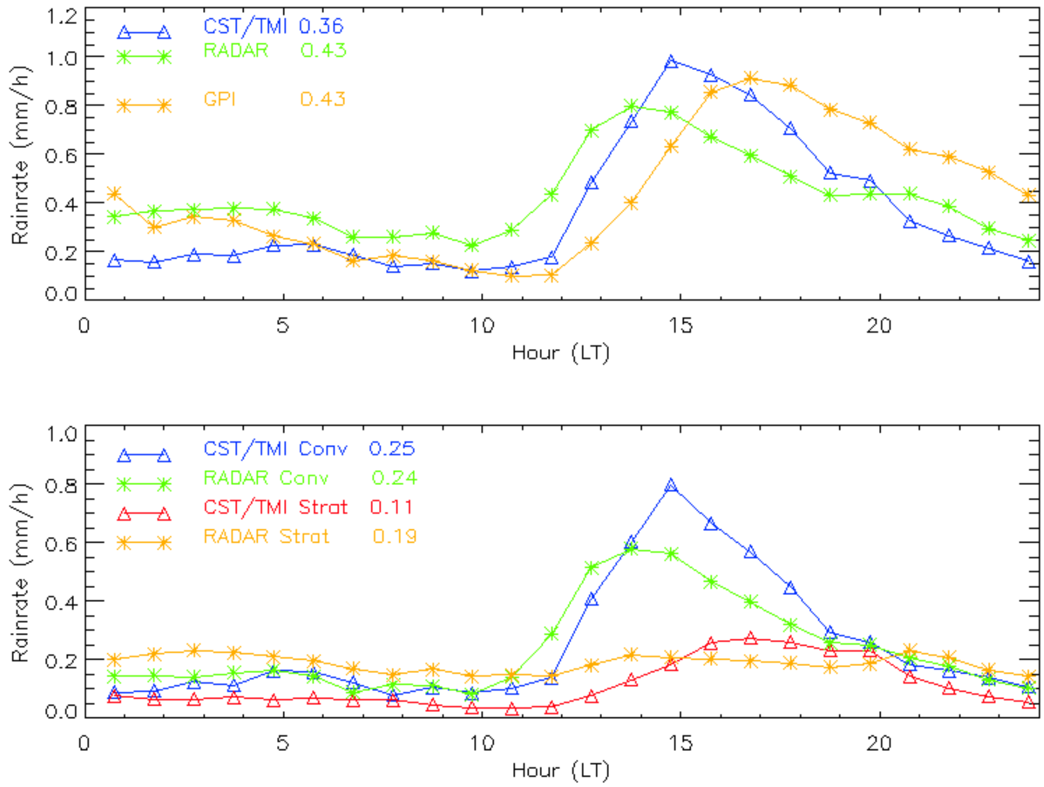

Figure 2. Diurnal cycle of total precipitation (top) and convective/stratiform components (bottom) from the CST//TMI method and the GOES Precipitation Index (GPI) compared to estimates from the NCAR radar. Data is for the radar area of the LBA experiment in Rondonia, Brazil during Jan.-Feb.1999

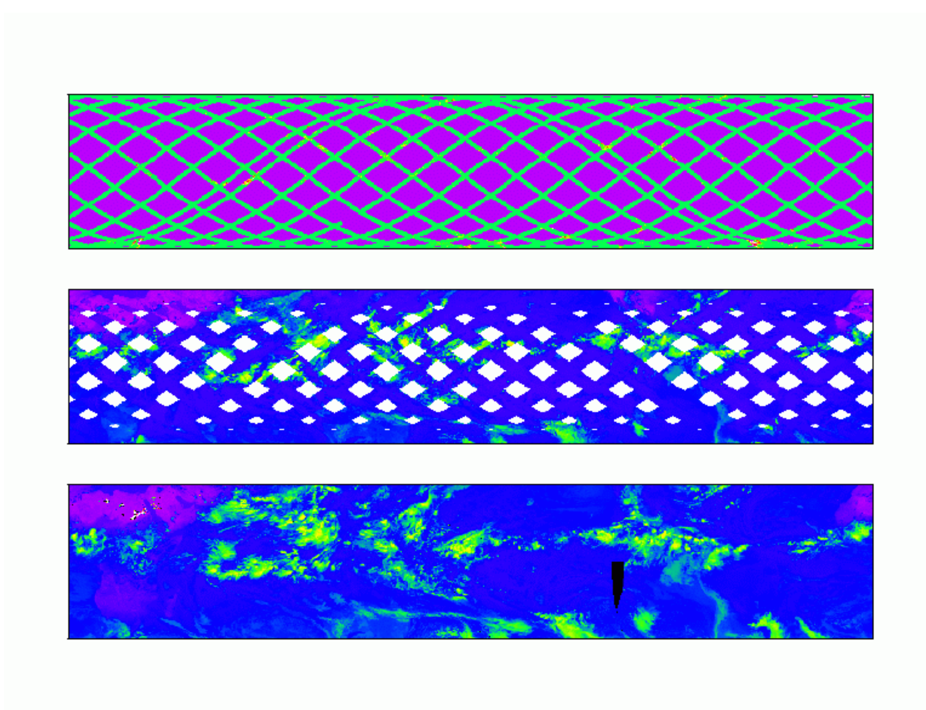

Figure 3: Top: TRMM Precipitation Radar (PR) orbits in one day; Middle: Infrared data from TRMM Visible and Infrared Scanner (VIRS) orbits in one day; Bottom: NOAA NCEP Global IR image merged from five geostationary satellites.

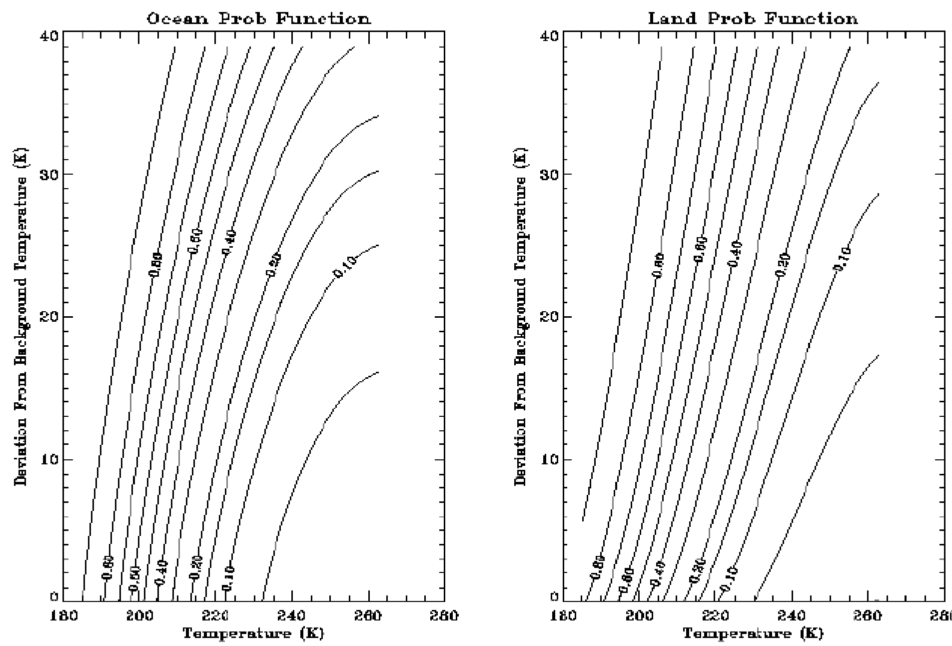

Figure 4: Probabilities (derived from TRMM PR) of convective rainfall for a given point of minimum temperature and deviation from background temperature). Oceanic and land probabilities are computed separately.

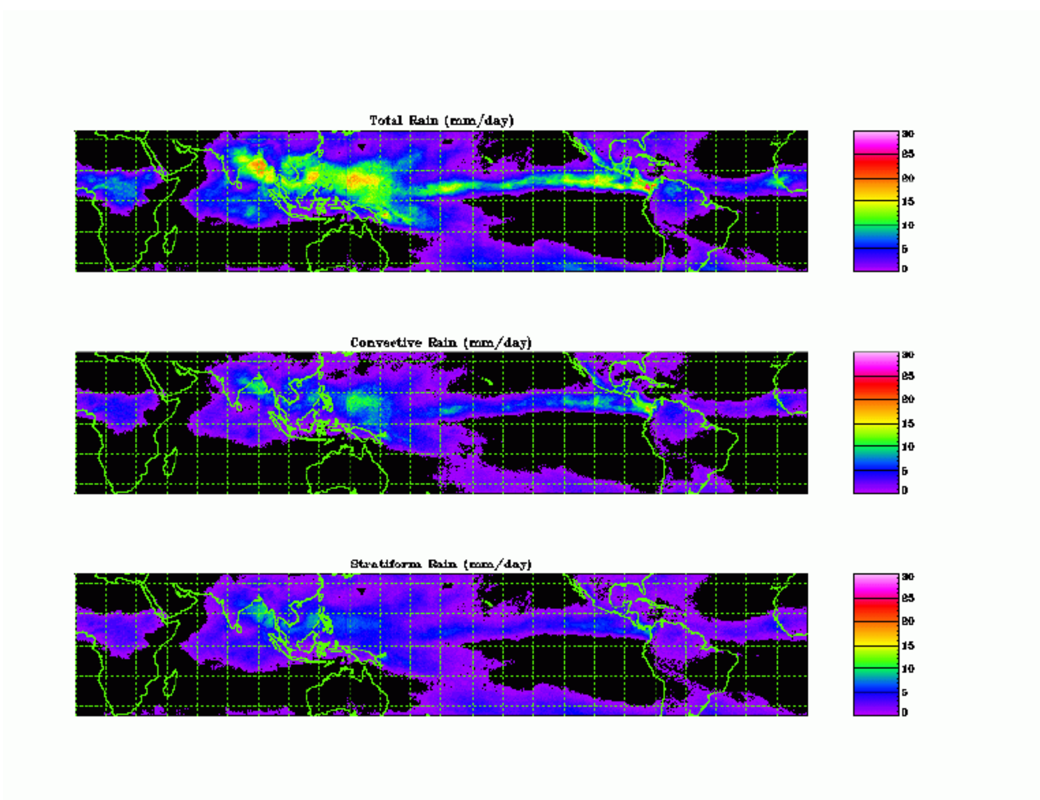

Figure 5. Rainfall estimates (mm/day) for June-July-August 2001 derived from the CST/PR method

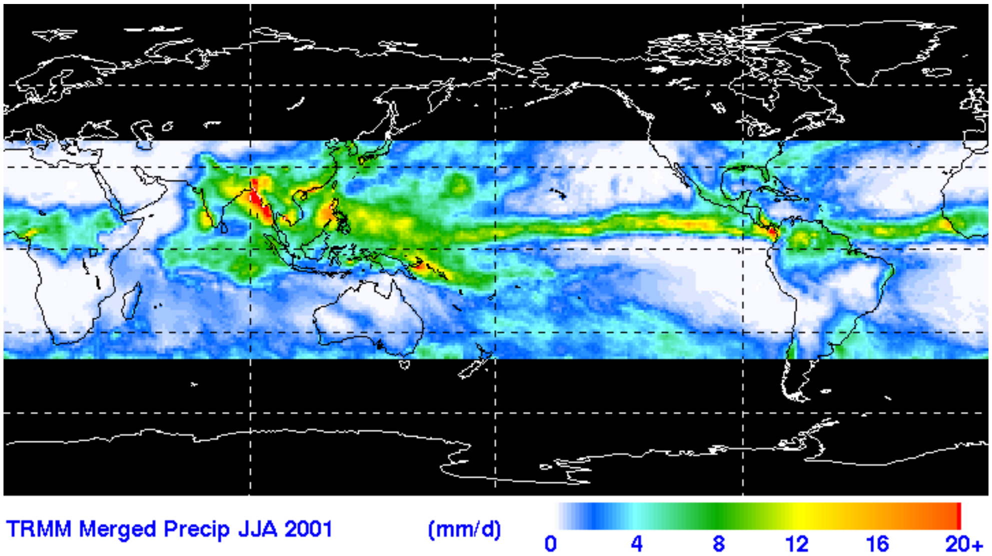

Figure 6. Rainfall estimates (mm/day) for June-July-August 2001 derived from The TRMM algorithm 3B43

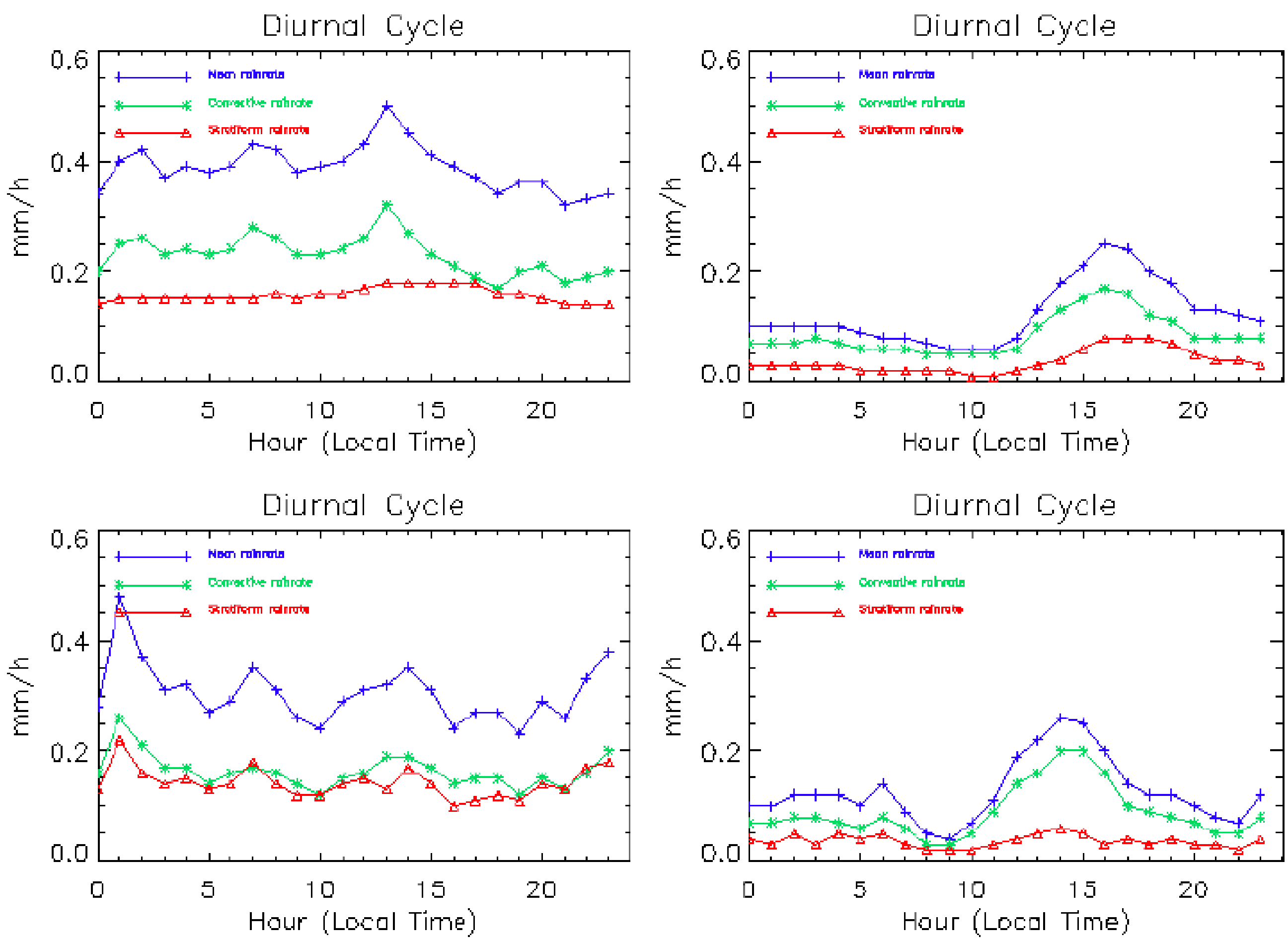

Figure 7. Top: Diurnal cycle of precipitation estimated by the CST/PR for the Western Pacific Ocean (left) and Amazon Basin (right) for June-Jul-Aug 2001. Bottom: Same except estimates from the TRMM PR for the 4-year period Jan. 1998 – Dec. 2001.

3. CONCLUSIONS

The objectives of this paper were to present results from an infrared technique (the CST) calibrated by the TRMM Microwave imager (TMI) over Brazil and to also present work-in-progress:

- Application of the Convective-Stratiform Technique (CST) to NOAA/NCEP global infrared (IR) data.
- Calibration of IR by TRMM Precipitation Radar (PR) data.
- Complement/enhance the estimates of current TRMM and GPCP products
- Produce high resolution results (hourly, 4 km)
- Delineation of the diurnal cycle of precipitation
- Partition of rainfall into convective and stratiform components to estimate the vertical profile of latent heating

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4. BIBLIOGRAPHIC REFERENCES

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