Further improvement of an orographic/nonorographic rainfall classification scheme in the GSMaP algorithm for microwave radiometers

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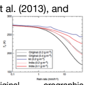
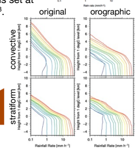
Introduction

<u>The orographic/non-orographic rainfall classification scheme has been implemented in the latest GSMaP algorithm</u> for passive microwave radiometers (Yamamoto and Shige, 2015). The scheme is switched off for regions (e.g. the Sierra Madre Mountains in the United States and Mexico) where strong lightning activity occurs in the rainfall type database because deep convective systems for the regions are detected from the scheme involved in the orographic rain condition. The scheme improves rainfall estimation over the entire Asian region, particularly over the Asian region dominating shallow orographic rainfall. However, overestimation and false-positive of orographic rainfall remain. This is because the orographic rainfall conditions have **<u>moderate thresholds for global application</u>**. We examine to resolve their problems (Caveat for Use of GPM-GSMaP).

Orographic/nonorographic rainfall classification scheme

- The orographic/nonorographic rainfall classification scheme has been implemented since this standard version of GSMaP algorithm for passive microwave radiometers (Yamamoto and Shige, 2015).
  - This is a revised scheme developed by Shige et al. (2013), Taniguchi et al. (2013), and Shige et al. (2015).
  - LUT switches from the original rain type to an orographic one when both of the conditions (orographically forced upward motion w (> 0.01 m s^{-1}) and moisture flux convergence Q (> 0.3 10^{-6} s^{-1})) are satisfied.
  - Precipitation-size ice particle density for orographic rainfall is set at 100 kg m^{-3} and that for non-orographic rainfall is 400 kg m^{-3}.
  - The scheme is switched off for regions where strong lightning activity occurs in the rainfall type database.



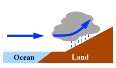


- Orographically forced upward motion

$$w = \frac{Dh}{Dt} = u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y}$$

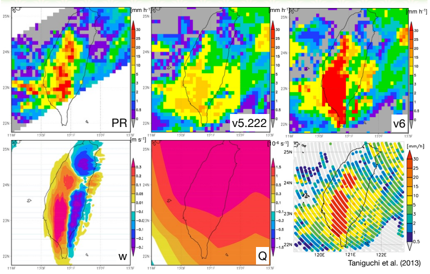
- Convergence of surface moisture flux

$$Q = -\left(\frac{\partial(uq)}{\partial x} + \frac{\partial(vq)}{\partial y}\right)$$



Yamamoto and Shige (2015): http://dx.doi.org/10.1016/j.atmosres.2014.07.024

Typhoon Morakot (2009)



Taniguchi et al. (2013)

- This scheme improves rainfall estimation over the entire Asian region.
- Overestimation and false-positive for global application (Caveat for Use of GPM-GSMaP).

➡Taniguchi et al. (2013) determined the thresholds of orographic rainfall condition as w > 0.1 m s^{-1} and Q > 0.5 10^{-6} s^{-1} for JCDAS data. For global application, the thresholds is moderated as w > 0.01 m s^{-1} and Q > 0.3 10^{-6} s^{-1}.

Points of improvement

- Orographic rainfall detection
  - The input wind in w and Q is used not only at the surface but also upper level.
    - Orographically forced upward motion (w)

$$w = \frac{Dh}{Dt} = u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y}$$

h: Terrain Height
u, v: Mean horizontal wind at the sfc. and 1.5 km from sfc.

- Convergence of surface moisture flux (Q)

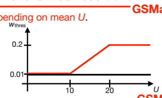
$$Q = -\left(\frac{\partial(uq)}{\partial x} + \frac{\partial(vq)}{\partial y}\right)$$

q: Surface water vapor mixing ratio
u, v: Mean horizontal wind at the sfc. and 1.5 km from sfc.

GSMaP2

- The threshold of w become variable depending on mean U.

weight = (U - 20) / (20 - 10), 0 ≤ weight ≤ 1
w_{thres} = 0.01 + weight * 0.19



GSMaP3

- A new index, static stability of the lower atmosphere (Shige and Kummerow 2014), is introduced.

$$\frac{dTv}{dz} = (T_{v4.5\mathrm{km}} - T_{v1.5\mathrm{km}})/3$$

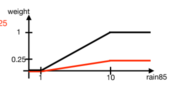
T_v: Virtual temperature

- The thresholds are changed and exclusion of high lightning rain types is abolished.
  0.01 ≤ w ≤ 0.2, Q > 0.~~3~~1 10^{-6} s^{-1}, and dTv/dz > -5.5 K km^{-1}

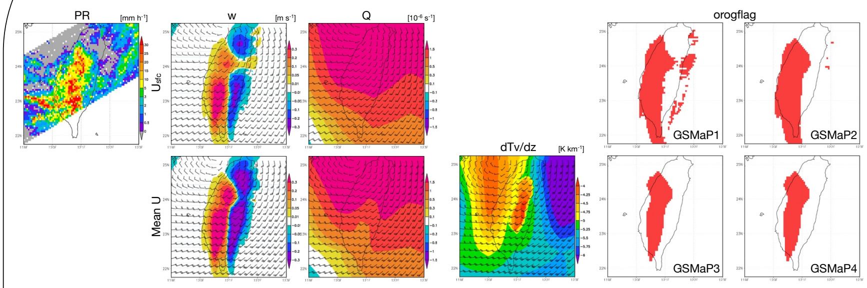
GSMaP4

- Orographic rainfall estimation
  - $Rain_{orog}$ adjusting weight in Rain37 is changed.

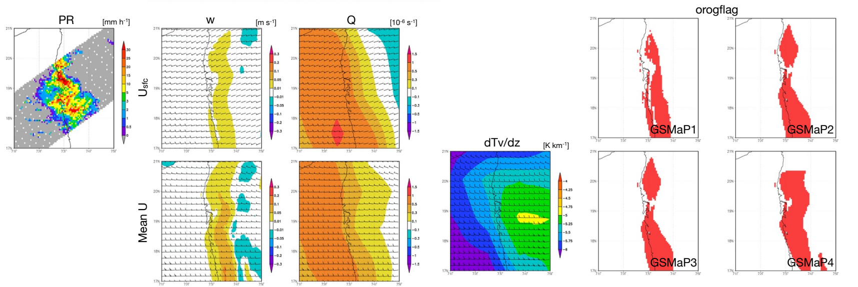
weight = (rain85 - 1.0) / (10.0 - 1.0), 0 ≤ weight ≤ ~~1~~ 0.25
$Rain_{orog}$ = weight * rain85 + (1.0 - weight) * rain37



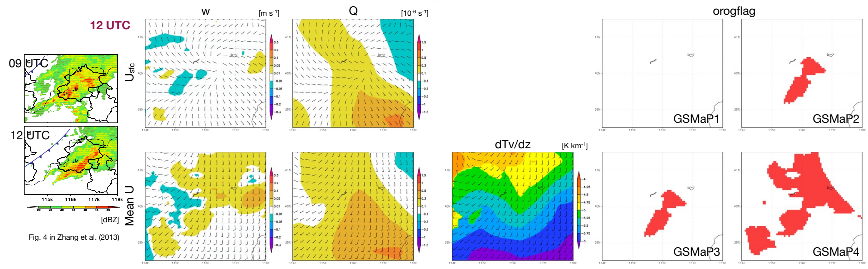
2009.08.08 Typhoon Morakot



2007.06.30 Heavy rainfall in India

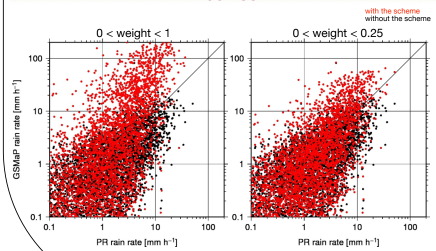


2012.07.20 Beijing extreme rainfall



"The observed rainfall was mostly generated by convective cells that were triggered by local topography and then propagated along a quasi-stationary linear convective system into Beijing."

PR rain rate vs GSMaP rain rate under the orographic rainfall condition in 2007 JJA



Summaries

- The orographic/non-orographic rainfall classification scheme has been implemented in the latest GSMaP algorithm for passive microwave radiometers (Yamamoto and Shige, 2015). However, overestimation and false-positive of orographic rainfall remain. This is because the orographic rainfall conditions have moderate thresholds for global application.
- The scheme is improved and will be implemented for the next revision.
  - The input wind in w and Q is used not only at the surface but also upper level.
  - The threshold of w become variable depending on mean U.
  - A new index, static stability of the lower atmosphere, is introduced.
  - The thresholds are changed and exclusion of high lightning rain types is abolished.
  - $Rain_{orog}$ adjusting weight in Rain37 is changed.