Investigation of cloud microphysical parameters in defining regional precipitating clouds

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Regional Investigation

• Exploration of satellite-derived cloud products and rainfall products

• Can a link be clarified?

• Is there an improvement in the classification of potential precipitating clouds with the addition of new microphysical cloud products that are being developed for new sensors?

• Classification definitions can be compared for differing climatic regions as well as comparing cloud frequencies in years with above and below average rainfall

• PRC = potential rain/precipitating cloud
Data

• HIRS/2 (High-resolution Infrared Radiation Sounder)
  • 2pm Equator crossing time orbit
  • 1985 to 2001
  http://www.ssec.wisc.edu/~donw/PAGE/CLIMATE.HTM

• MODIS (Moderate-resolution Imaging Spectroradiometer)
  • Aqua C5.1, C6.1
  • 2002 to 2018
  • https://ladsweb.modaps.eosdis.nasa.gov/search/

• GPCP (Global Precipitation Climatology Project): V2.2, V2.3
  • 1985 to 2018
  • https://www.esrl.noaa.gov/psd/data/gridded/data.gpcp.html

• Wet vs Dry – above and below average regional rainfall based on the 1981-2010 climate normal
Southwest and Kimberley regions in WA

- **SWWA** – temperate climate with majority of rainfall falling during Southern Hemisphere winter months. Highest rainfall months are May, June, July, August and September.

- Kimberley – tropical climate with majority of rainfall falling during monsoonal wet season (during Southern Hemisphere summer months). Highest rainfall months are December, January, February and March.
HIRS regional study

• Two parameters, Cloud Top Pressure (CTP) and Cloud Effective Emissivity (CEE)
• 1985 to 2001
• 1 parameter: CEE > 0.75; based on research by Menzel (1990) where there was increased proficiency in distinguishing precipitating and non-precipitating events during the Global Tropospheric Experiment: Amazon Boundary Layer Expedition 2B (1987)
• 2 parameters: CEE > 0.75, CTP < 700 hPa; removing low lying clouds

• Menzel, W. P. (1990), VAS determination of diurnal cloud cover characteristics over Amazonia. [document provided by author as companion piece to (Menzel et al. 1990)].
HIRS results for region highest rainfall months

**SWWA**

- **1 parameter: CEE > 0.75**
  - Wet years: 38% PRC freq.; $R^2 = 0.19$
  - Dry years: 37% PRC freq.; $R^2 = 0.00$

- **2 parameters: CEE > 0.75, CTP < 700 hPa**
  - Wet years: 11% PRC freq.; $R^2 = 0.17$
  - Dry years: 10% PRC freq.; $R^2 = 0.04$
HIRS results for region highest rainfall months

Kimberley

• 1 parameter: CEE > 0.75
  • Wet years: 44% PRC freq.; $R^2 = 0.51$
  • Dry years: 40% PRC freq.; $R^2 = 0.30$

• 2 parameters: CEE > 0.75, CTP < 700 hPa
  • Wet years: 25% PRC freq.; $R^2 = 0.68$
  • Dry years: 20% PRC freq.; $R^2 = 0.51$
MODIS regional study

• 2 parameters
  • Cloud Effective Emissivity (CEE)
  • Cloud Top Pressure (CTP)

• 5 parameters
  • Cloud Effective Emissivity (CEE)
  • Cloud Top Pressure CTP
  • Cloud Effective Radius (CER)
  • Cloud Optical Thickness (COT)
  • Cloud Top Temperature (CTT)

• 2002 to 2015 (extending and upgrading to C6.1, V2.3 ->2018)
Range of MODIS cloud parameters

- Cloud Top Pressure (CTP) 100 hPa - 950 hPa (50 hPa)
- Cloud Effective Emissivity (CEE) 0.50 – 0.95 (0.05)
- Cloud Effective Radius (CER) 5 μm – 25 μm (1 μm)
- Cloud Optical Thickness (COT) 1 – 30 (1)
- Cloud Top Temperature (CTT) 205 K – 285 K (1 K)
MODIS results for region highest rainfall months

**SWWA**

- 2 parameters: CEE > 0.75, CTP < 700 hPa
  - Wet years: 36% PRC freq.; $R^2 = 0.46$
  - Dry years: 35% PRC freq.; $R^2 = 0.13$
  - 1% more PRCs in Wet years

- 5 parameters: CEE > 0.55, CTP < 900 hPa, CER > 15 μm, COT > 20 and CTT < 276 K
  - Wet years: 29% PRC freq.; $R^2 = 0.60$
  - Dry years: 26% PRC freq.; $R^2 = 0.78$
  - 3% more PRCs in Wet years
MODIS results for region highest rainfall months

Kimberley

• 2 parameters: CEE > 0.75, CTP < 700 hPa
  • Wet years: 81% PRC freq.; $R^2 = 0.52$
  • Dry years: 77% PRC freq.; $R^2 = 0.57$
  • 4% more PRCs in Wet years

• 5 parameters: CEE > 0.75, CTP < 450 hPa, CER > 18 μm, COT > 2 and CTT < 254 K
  • Wet years: 52% PRC freq.; $R^2 = 0.86$
  • Dry years: 36% PRC freq.; $R^2 = 0.87$
  • 16% more PRCs in Wet years
MODIS results for region highest rainfall months – SWWA, 5 parameters

- CEE > 0.65, CTP < 800 hPa, CER > 22 μm, COT > 13 and CTT < 271 K
  Wet years: 10% PRC freq.; $R^2 = 0.76$

- CEE > 0.70, CTP < 900 hPa, CER > 19 μm, COT > 20 and CTT < 279 K
  Dry years: 19% PRC freq.; $R^2 = 0.86$
MODIS results for region highest rainfall months – Kimberley, 5 parameters

• CEE > 0.75, CTP < 250 hPa, CER > 18 μm, COT > 3 and CTT < 231 K

Wet years: 40% PRC freq.; $R^2 = 0.90$

• CEE > 0.75, CTP < 500 hPa, CER > 18 μm, COT > 3 and CTT < 262 K

Dry years: 38% PRC freq.; $R^2 = 0.92$
SWWA vs Kimberley

- Overall, the extension of the classification scheme to include cloud physical and microphysical properties has substantially improved the characterisation of PRCs in the SWWA and Kimberley regions.

- As definitions approach the characteristics of precipitating clouds, above and below average rainfall year differences can be clarified.

- In the SWWA: Wet year PRCs have a slightly larger CER, and are higher and cooler than Dry year PRCs. Dry year PRCs are thicker and more opaque.

- In the Kimberley: Wet years have cooler PRCs with an increased presence higher in the atmosphere than Dry years.

- Regional differences: SWWA PRCs are lower and warmer than those in the Kimberley and require a larger COT to produce the highest alignment with rainfall.
Preliminary results – upgrading data versions

**SWWA**
- MODIS C5.1, GPCP V2.2
  - 2002-2015
  - 2 parameters: CEE > 0.75, CTP < 700 hPa
    - Wet years: 36% PRC freq.; $R^2 = 0.46$
    - Dry years: 35% PRC freq.; $R^2 = 0.13$
- MODIS C6.1, GPCP V2.3
  - 2002-2018
  - 2 parameters: CEE > 0.75, CTP < 700 hPa
    - Wet years: 38% PRC freq.; $R^2 = 0.41$
    - Dry years: 39% PRC freq.; $R^2 = 0.24$