Comparison of tropical convective systems life cycle characteristics from geostationary and TRMM observations for the West African, Indian and South American regions

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Deep Convective Systems in the Tropics

Organized cloud clusters span a wide range of spatial scale and degree of organization.

Variety of organized convection

Convective precipitation
Stratiform precipitation

Cold cloud shield

Dimension > 100km
The life cycle of the mesoscale convective system

Initiation
- Evolution of the cold cloud shield
  ➔ Importance for the radiative budget

Maturity
- Evolution of the convective and stratiform precipitations associated to the MCS
  ➔ Importance for the heat budget

Dissipation

Quantification of the life cycle phases durations for the entire monsoonal region of West Africa, India and South America
Composite of the life cycle of the MCSs

Inputs and Algorithm: a Megha-Tropiques product

<table>
<thead>
<tr>
<th>Region</th>
<th>Satellite(s)</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Africa</td>
<td>METEOSAT-7, MSG-2</td>
<td>from June to September 2002-2005, from June to September 2010</td>
</tr>
<tr>
<td>India</td>
<td>METEOSAT-5</td>
<td>from June to September 2002-2005</td>
</tr>
<tr>
<td>South America</td>
<td>GOES-12</td>
<td>from November 2011 to March 2012</td>
</tr>
</tbody>
</table>
Suppression of Split and merge artefacts during the MCS life cycle.

Detection of the convective systems earlier in their triggering stage and later in their dissipation stages

Improvement of the characterization of the main morphological aspects of the MCS

http://meghatropiques.ipsl.polytechnique.fr/tools/Niamey/
General MCS population statistics

3B42 accumulated rainfall (mm/h)

Cold Cloudiness (hr/month)

MCS Population
Life cycle analysis and MCS classification

Normalization and discretization of the life cycle in 10 steps

Classification of the MCS

| MCS Lifetime > 5h |  
|-------------------|------------------|
| **Population**    | **Cold cloudiness** |
| 76%               | 98.5%            |

| MCS describing only one maximum along their life cycle |  
|------------------------------------------------------|------------------|
| **Population** | **Cold cloudiness** |
| 76%            | 77%               |

Linear Growth and Decay model

- **Duration**
- **$S_{max}$**
- **$T_{max}$**

Two thirds of the MCS describe a symmetric evolution of their surfaces
Scale factors of the linear model

Important variability of $<S_{\text{max}}>$

A simple classification of MCS in Continental/Oceanic categories not well adapted to observe regional specificities

MCS classification according to 8 regions of interests
The evolution of the cold cloud shield associated to the MCS can be simplified and can be characterized by **only one degree of freedom (Smax)**.

- **Strong correlation** between $S_{\text{max}}$ and the lifetime duration in each region of study.
- $T_{\text{max}}$ constant $\sim$50%
Evolution of the precipitations associated to the MCSs

Sampling of MCS with the data derived from TMI onboard TRMM

TRMM Data Surface Rainfall: BRAIN product

- Surface rainfall (mm/h)
- Convective rain fraction (%)

2010-07-20 06h00
2010-08-03 22h30
2010-08-01 23h00
Evolution of the precipitations associated to the MCSs

1 - Stability of the precipitating area fraction up to 50% of the normalized life cycle
2 – Decrease of the precipitating area fraction

1 – Increase of the convective rain fraction up to [20%-30%] of the normalized life cycle
2 – Decrease of the convective rain fraction

Similar evolution of the Precipitating area fraction and the convective rain fraction over the 8 regions.

The evolutions of the precipitation associated to MCS are dependant to regional scale factors
Evolution of the precipitations associated to the MCSs

- Atlantic ocean
- Guinean coast
- Sahel
- West Bay of Bengal
- East Bay of Bengal
- Indian continent
- Indian Ocean
- Northern of South America
- Southern of South America
Quantification of the life cycle phases durations for the 8 regions of study

Idealized conceptual model of the MCS life cycle

Evolution of the precipitating structure associated to the MCS

Scale factors:
- $T_{\text{max}}$ constant $\sim 50\%$
- Strong correlation between Smax and lifetime duration

Evolution of the cold cloud shield associated to the MCS

Scale factors:
- $f_p$: precipitating fraction
- $f_c$: convective rain fraction

Quantification of the life cycle phases durations for the 8 regions of study
### Idealized conceptual model of the MCS life cycle

<table>
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<th>Régions</th>
<th>$&lt;S_{\text{max}}&gt;$ (km²)</th>
<th>$&lt;fp&gt;$ (%)</th>
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<tr>
<td>Océan Atlantique ITCZ</td>
<td>14474</td>
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#### Graphs

**Atlantic ocean**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**

**Guinean Coast**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**

**Sahel**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**

**Bay of Bengal**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**

**Indian Ocean**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**

**Southern of South America**

- **Surface (km²)**: 40000
- **Tmax**
- **Durée de vie (h)**
Conclusion

- a simple classification of MCS in **Continental/Oceanic categories not well adapted to observe regional specificities**

- **Similar evolution** of the cold cloud shield and precipitating structures associated to MCS over the 8 regions of interest in West Africa, India and South America

- **idealized conceptual Model of MCS**:

  1. **Initiation**; 25% of the life cycle
     - Increase of the **MCS area**
     - Increase of **fc**
     - Stability of **fp**

  2. **Maturity**; 25% of the life cycle
     - Increase of the **MCS area**
     - Decrease of **fc**
     - Stability of **fp**

  3. **Dissipation**; 50% of the life cycle
     - Decrease of the **MCS area**
     - Decrease of **fc**
     - Decrease of **fp**
Validation of the MCS idealized models and scale factors by merging the MCSs with meteorological radar data:

- Over Brazil
  - The CHUVA project (March 2010 – December 2014)
- Over Niamey
  - The ground validation campaign in August 2010
- Over the India ocean
  - The Dynamo campaign in November/December 2011
Fiolleau, T. and R. Roca, 2012, An algorithm for the detection and tracking of tropical mesoscale convective systems using infrared images from geostationary satellite, accepted to IEEE

## Idealized conceptual model of the MCS life cycle

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**Atlantic ocean**

- Tmax
- Durée de vie (h)

**Guinean Coast**

- Surface (km²)

**Sahel**

- Surface (km²)

**Bay of Bengal**

- Surface (km²)