Monitoring severe convection using passive microwave radiometry

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Atmospheric convection is a quasi global phenomenon which is often associated with severe weather.

Need for comprehensive and homogeneous monitoring of this phenomenon can be achieved using space borne instruments (radar, infrared sensors, microwave radiometers).

Microwave instruments are sensitive to hydrometeors and thus can be used to detect convection.

→ Passive and active microwave instruments (AMSU-B, MHS, Cloudsat)
MHS is a space borne passive *microwave radiometer*

- 5 channels: 2 window channels and 3 high frequency channels around the water vapour absorption line
- Swath-width of **2000 km** and nadir resolution of **16 km**
- Viewing angle from 0.6° to 60°
1/ High frequency channels probe in mid-atmosphere

2/ Frozen hydrometeors scatter Earth radiation at microwave high-frequencies

=> It is possible to detect heavy ice loading in mid-atmosphere signature of convection

- Using these characteristics, Hong et al. 2005, JGR developed 2 criteria of severe convection: deep convection and convective overshooting
A long term database

DC/COV criteria developed for AMSU-B but can be adapted to MHS/ATMS

- From 2002 onwards at least 3 satellites fly conjointly with MHS/ATMS/AMSU-B onboard

- Good temporal coverage with 3-4 hour resolution, crossing hours depend on the year/satellite

- It is possible to use these measurements to build a long-term and quasi global database of DC and COV
Evaluation and characterisation of Deep Convection and Convective Overshooting criteria

⚠️ DC/COV only assessed for cases studies over Amazonia and Florida
⚠️ No information about the microphysics of DC and COV

Objective: evaluate and characterise DC/COV criteria from 60°S/60°N

Dataset: 1/ Airborne radar collocated with MHS
        2/ Spaceborne radar (Cloudsat) collocated with MHS

27 October 2012

Heavy rain in Albania/Greece (>200 mm/36h)

DC and COV detected by MHS

High reflectivity measured by Cloudsat
Case study over Spain

- Colocation of MHS observations with an airborne X-band radar

- The aircraft sampled a convective cloud with **Deep Convection** and **Convective Overshooting** detected by MHS

- Within this cloud brightness temperatures reach low values (<180 K) because of ice scattering

- Maximum of reflectivity is found from 4 to 8 km in the COV region

*Rysman et al. 2016, QJRMS*
Evaluation and characterisation of Deep Convection and Convective Overshooting criteria

**Rationale**

> 50 000 MHS / CPR-Cloudsat *collocations* from 2006 to 2015

→ Cloudsat Cloud Scenario Classification product to evaluate the DC & COV criteria

→ Tropopause height provided by the Goddard Earth Observing System

• **DC valid** when associated with *Deep Convective Clouds*

• **COV valid** when associated with *Deep Convective Clouds* AND when the Deep Convective Clouds reach the Tropopause
Results
• Both criteria are associated with **Deep Convective Clouds** (as observed by Cloudsat) > 90% of time

• COV effectively reaches the Tropopause 51% of time
Evaluation and characterisation of Deep Convection and Convective Overshooting criteria

**Results**

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**False positive as a function of month**

- Problem in **frozen soil** regions (e.g., Siberia) and **mountain range**
- Effective radius quite similar for both diagnostics
- ER decreases rapidly with altitude
- Ice reaches lower altitude for DC
- Maximum of IWC is lower for COV
Data checking

Toward a climatology of Deep Convection and Convective Overshooting

Average number of DC occurrence
Data checking

→ Some problems are not documented
First climatology of Deep Convection and Convective Overshooting

- Range: 60°S/60°N
- Daily resolution
- 0.2°x 0.2° resolution

DC occurrence between 1999 and 2015
First climatology of Deep Convection and Convective Overshooting

- Range: 60°S/60°N
- Daily resolution
- 0.2°x 0.2° resolution

**January-March 2015**

**June-August 2015**

*Number of DC occurrence*
Conclusion

- We use spaceborne **passive microwave** instruments to detect convection.

- We **validated** and **characterized** the **convective events** detected by microwave sounders.

  => Passive microwave radiometers can be used to monitor convection from 60°S/60°N except in mountainous and frozen soil regions.

- We are building a **quasi-global climatology** of **convective events**.

- This climatology can be used for **model evaluation** (see Rysman et al. 2017 Clim Dyn).
Model evaluation using DC climatology

- Model: WRF decadal simulations
- Observations: AMSU-B/MHS and airborne radar

Simulated brightness temperatures (RTTOV radiative transfer model) show a bias when compared to observed BT

=> The model produces too few frozen hydrometeors and at too low altitude

Lead to an improved agreement between model and observations regarding convection

Rysman et al. 2017, Cl Dyn