GEWEX UTCC-PROES

Institute of Atmospheric Sciences and Climate
Roma

Monitoring severe convection using passive microwave radiometry

LMD
École Polytechnique Université Paris-Saclay
Institut Pierre Simon Laplace

JF Rysman, C. Claud, P. Drobinski,
S. Berthou, J. Delanoë,
JP. Chaboureau, B.M. Funatsu

Why and how monitoring convection ?

• **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**)

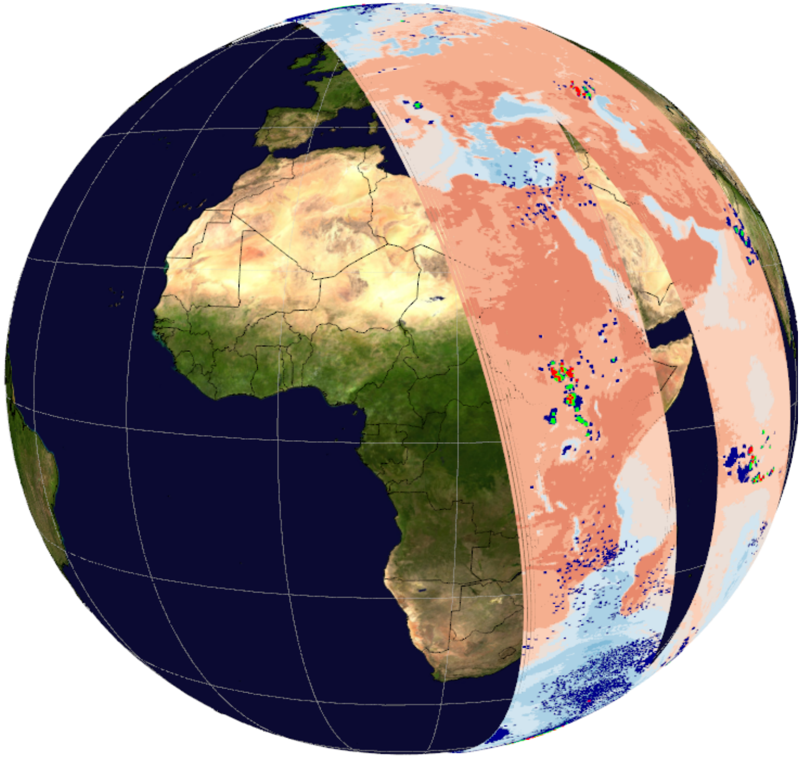
An instrument to detect convection: the Microwave Humidity Sounder

- 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°



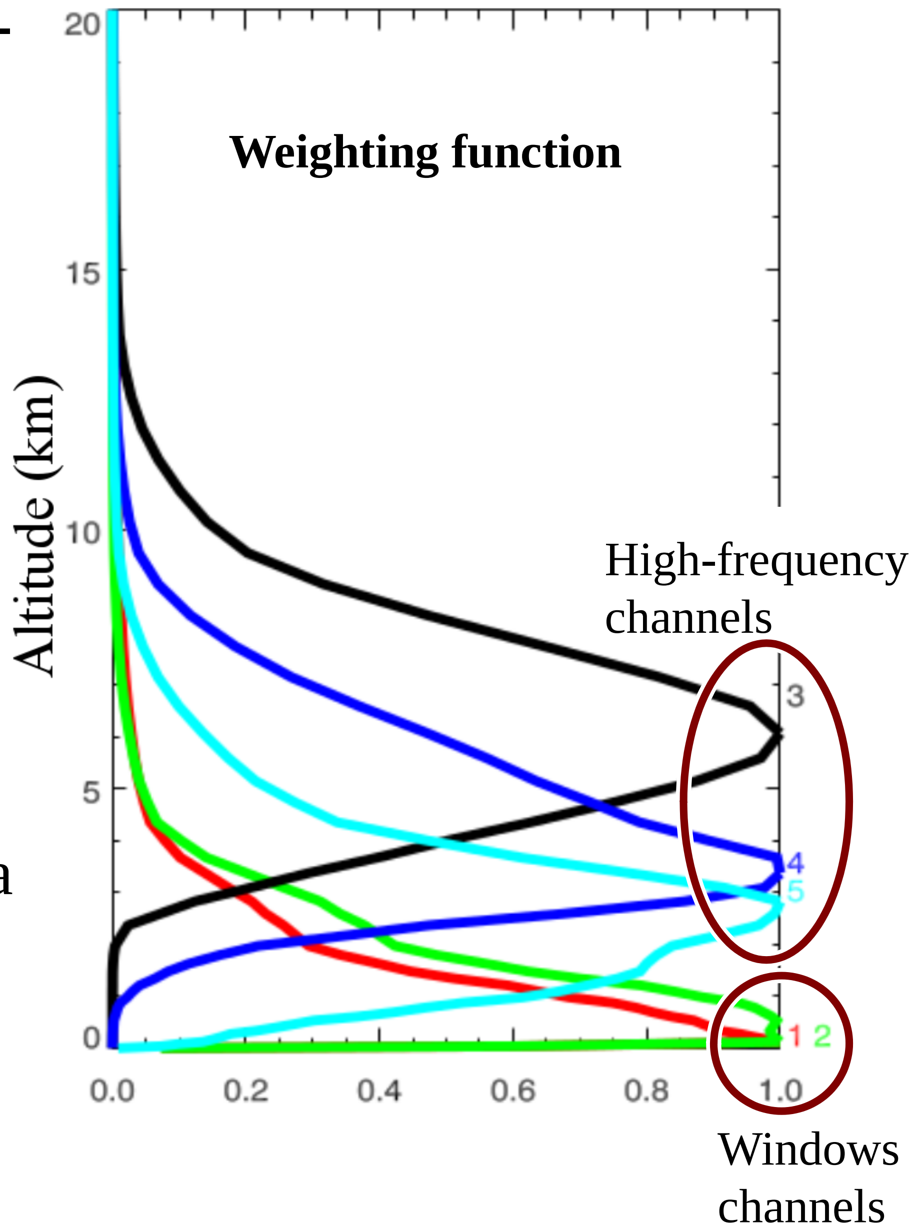
How to detect convection with passive microwave sounders ?

1/ High frequency channels probe in **mid-atmosphere**

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

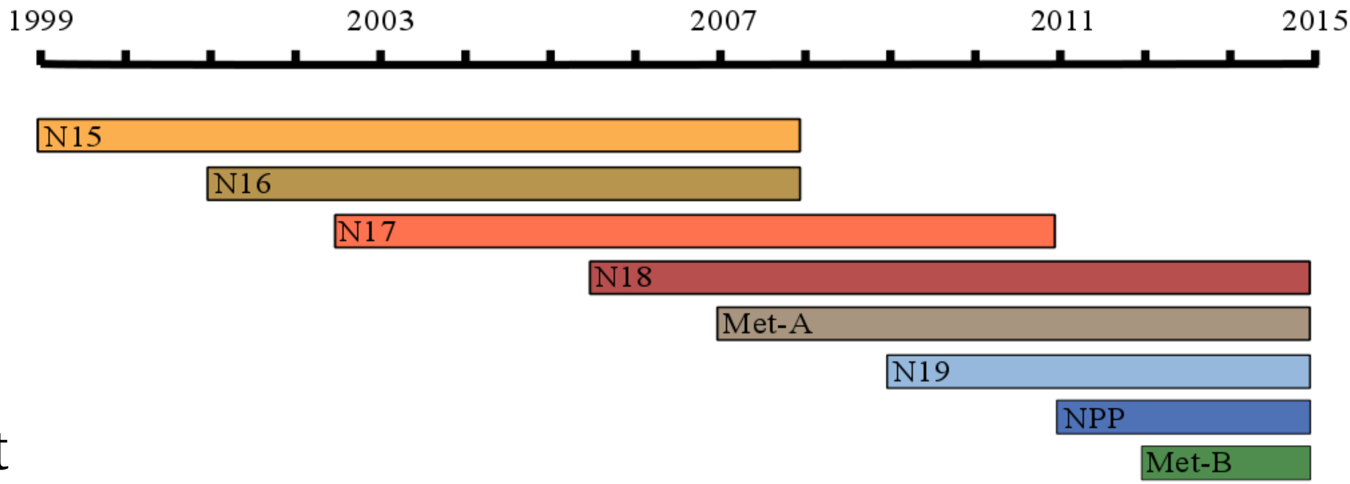
=> It is possible to detect heavy ice loading in mid-atmosphere signature of **convection**

- 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

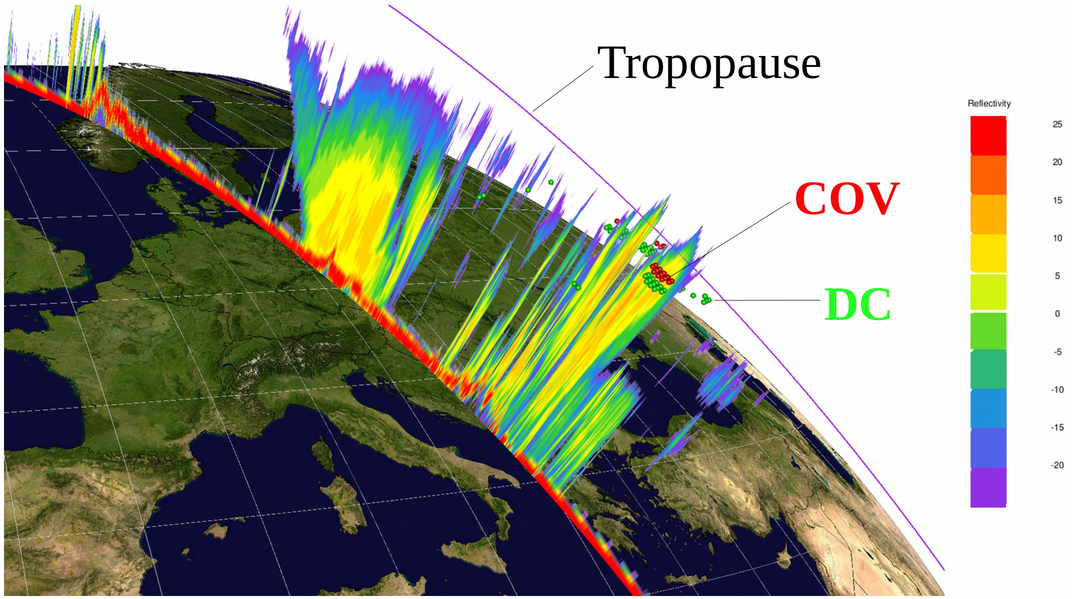
DC/COV only assessed for cases studies over **Amazonia** and **Florida**

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

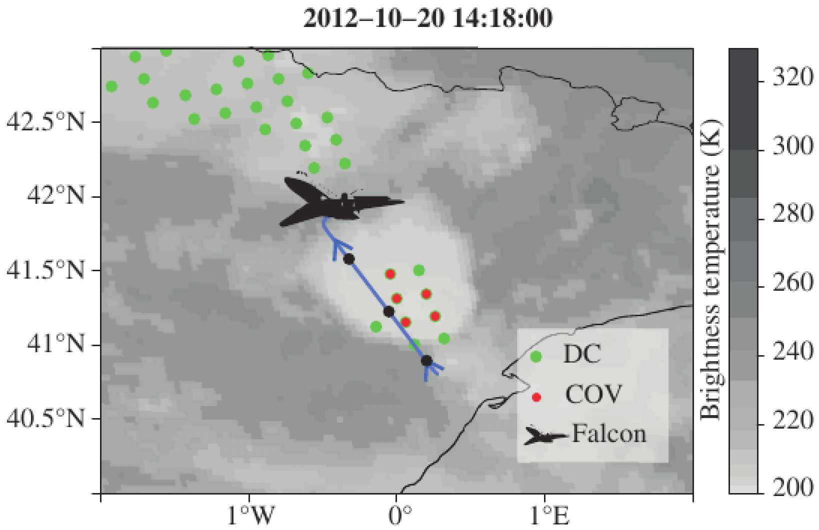
Heavy rain in Albania/Greece (>200 mm/36h)

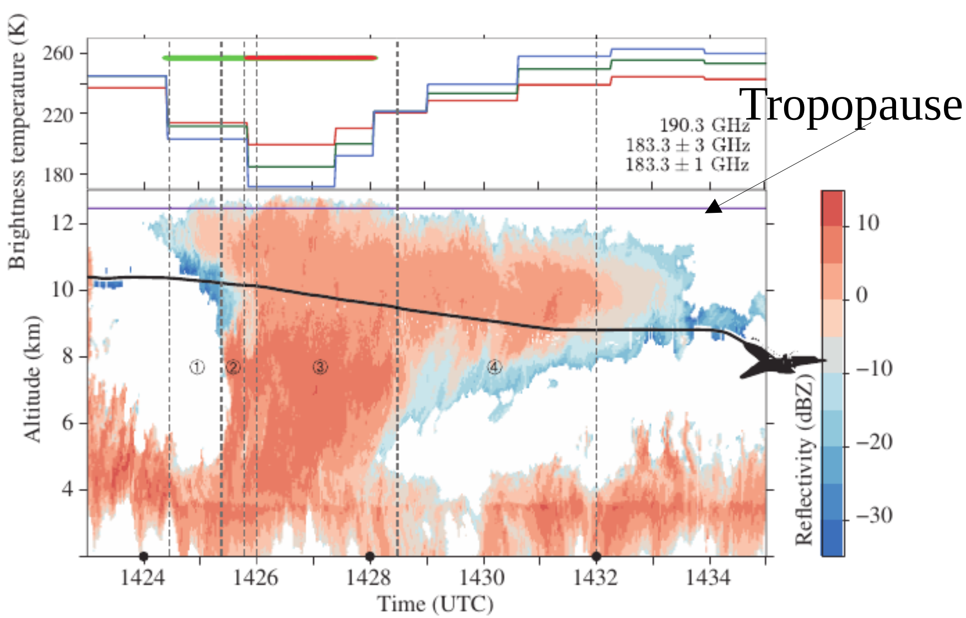
DC and COV detected by MHS

High reflectivity measured by Cloudsat

COV and DC criteria in the Mediterranean

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

Evaluation and characterisation of Deep Convection and Convective Overshooting criteria

Results

- Both criteria are associated with **Deep Convective Clouds** (as observed by Cloudsat) > 90% of time

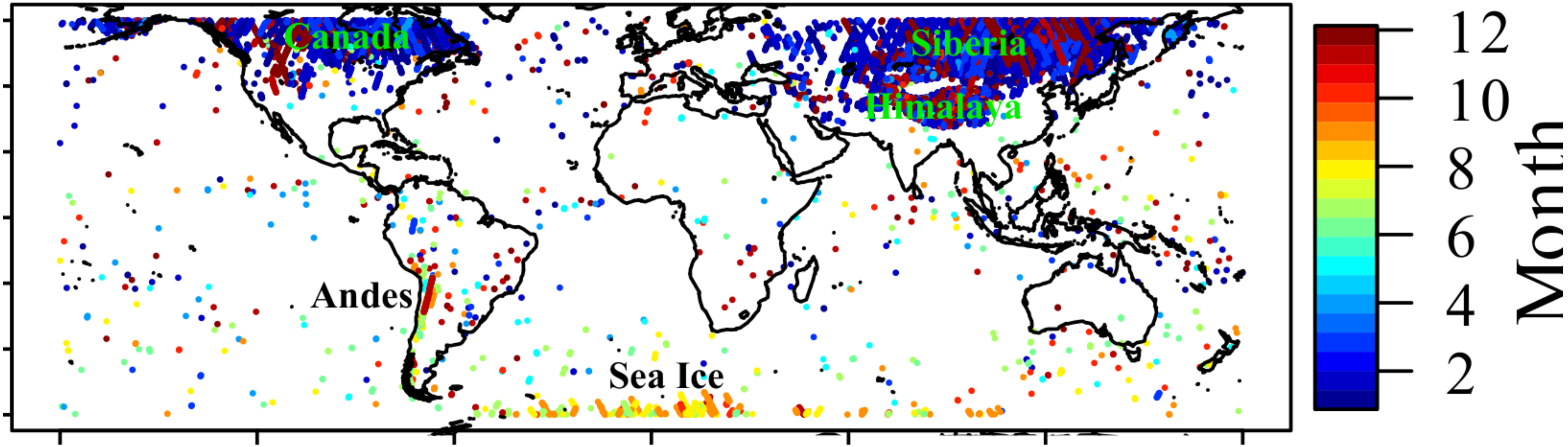
- COV effectively reaches the Tropopause 51% of time

Evaluation and characterisation of Deep Convection and Convective Overshooting criteria

Results

- Both criteria are associated with **Deep Convective Clouds** (as observed by Cloudsat) > 90% of time

- COV effectively reaches the Tropopause 51% of time

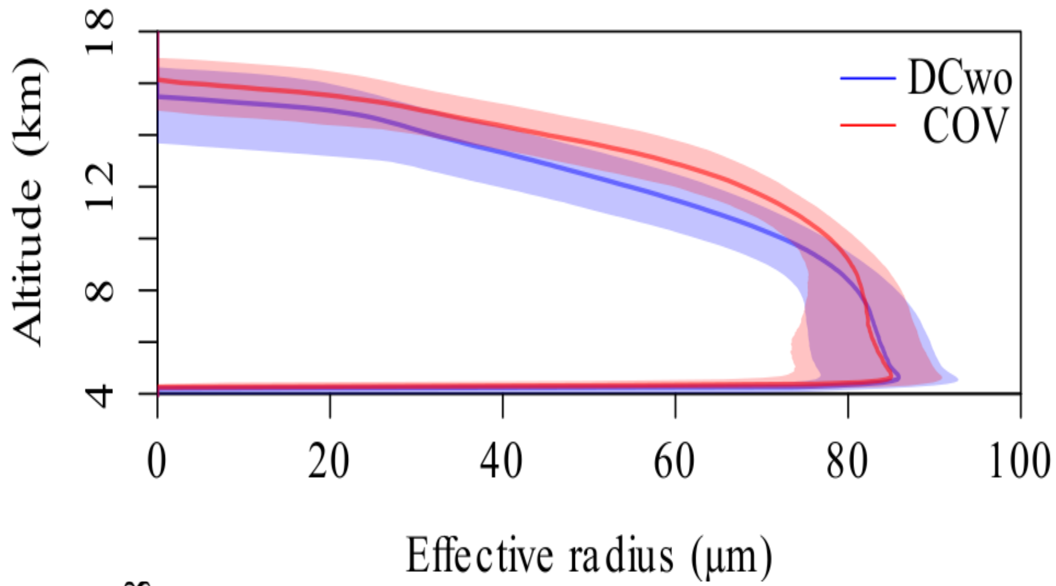


False positive as a function of month

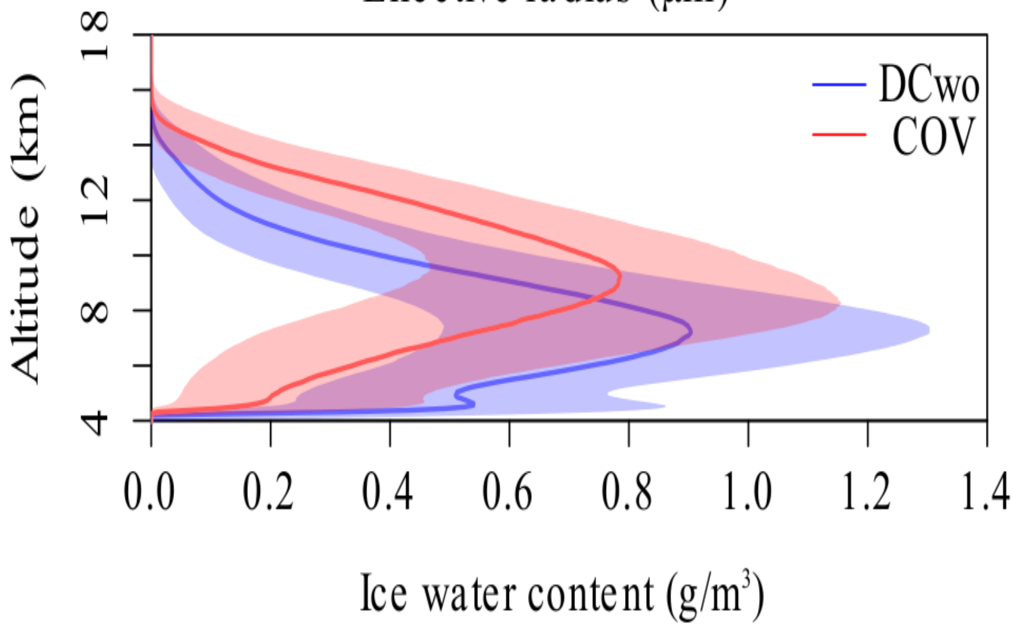
- Problem in **frozen soil** regions (e.g., Siberia) and **mountain range**

Rysman et al., 2018 IEEE GRSL

Microphysics of Deep Convection and Convective Overshooting



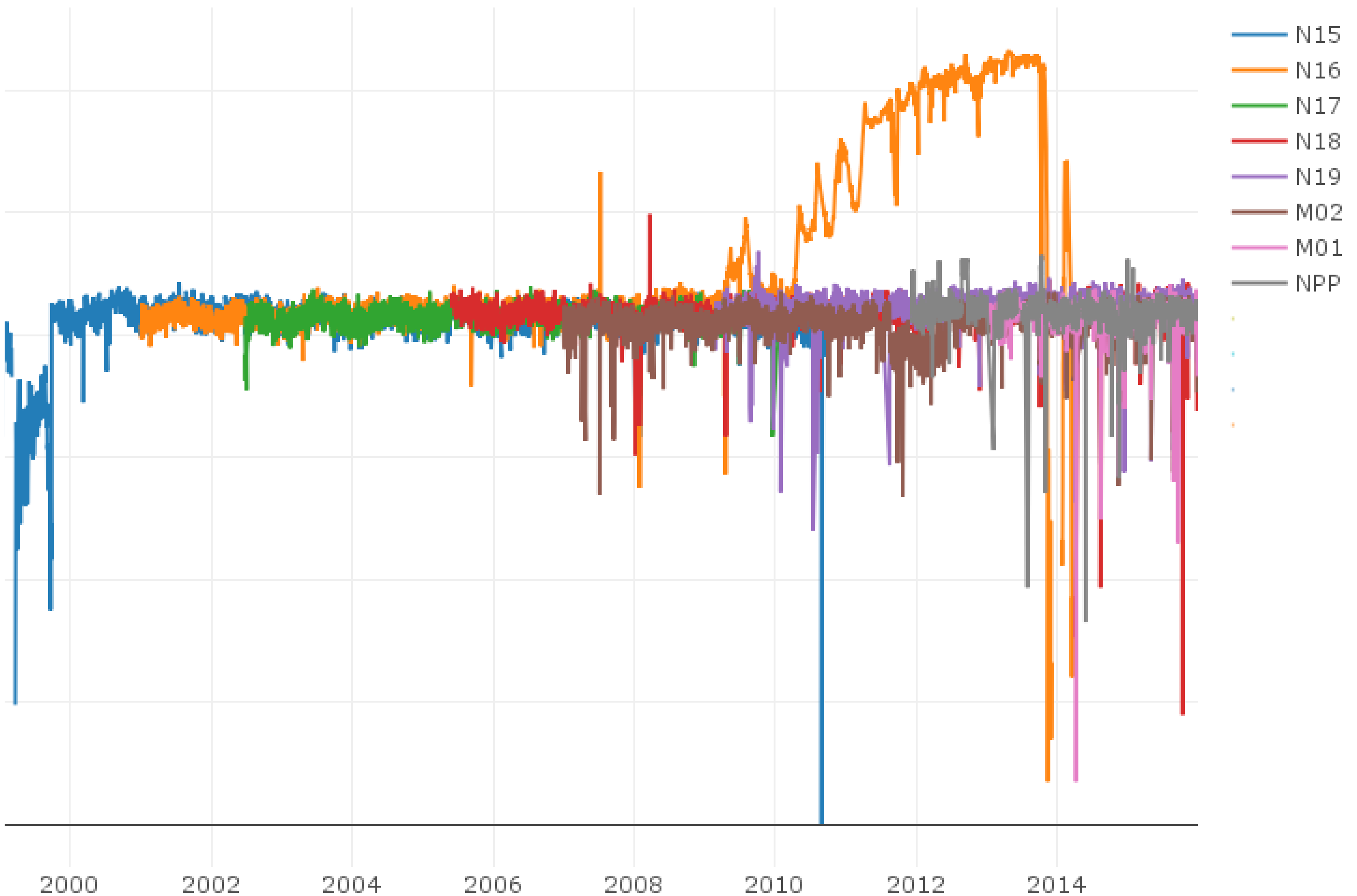
- Effective radius quite similar for both diagnostics
- ER decreases rapidly with altitude



- Ice reaches lower altitude for DC
- Maximum of IWC is lower for COV

Toward a climatology of Deep Convection and Convective Overshooting

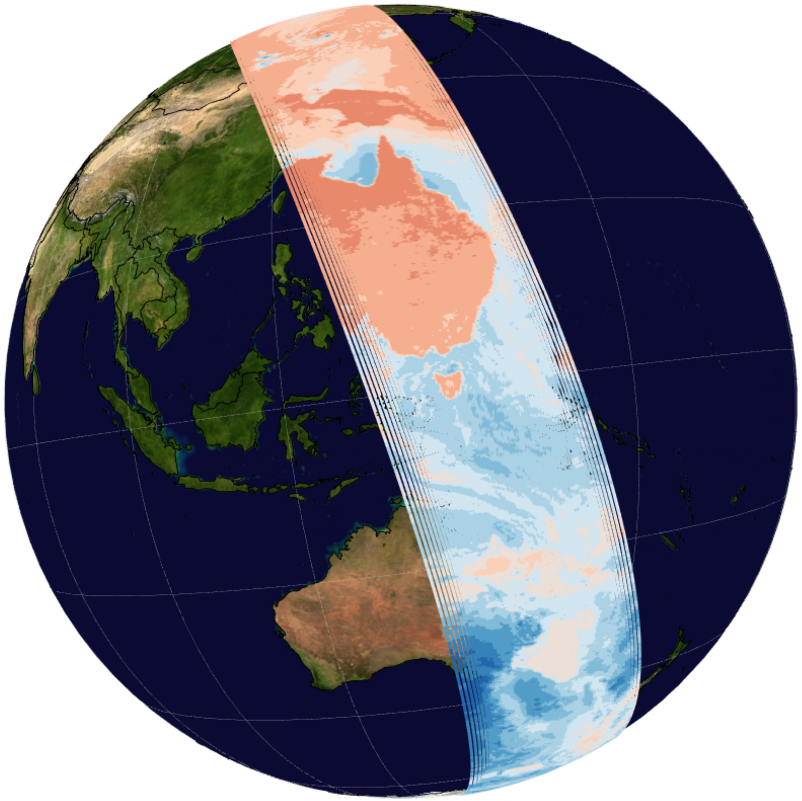
Data checking



Average number of DC occurrence

Data checking

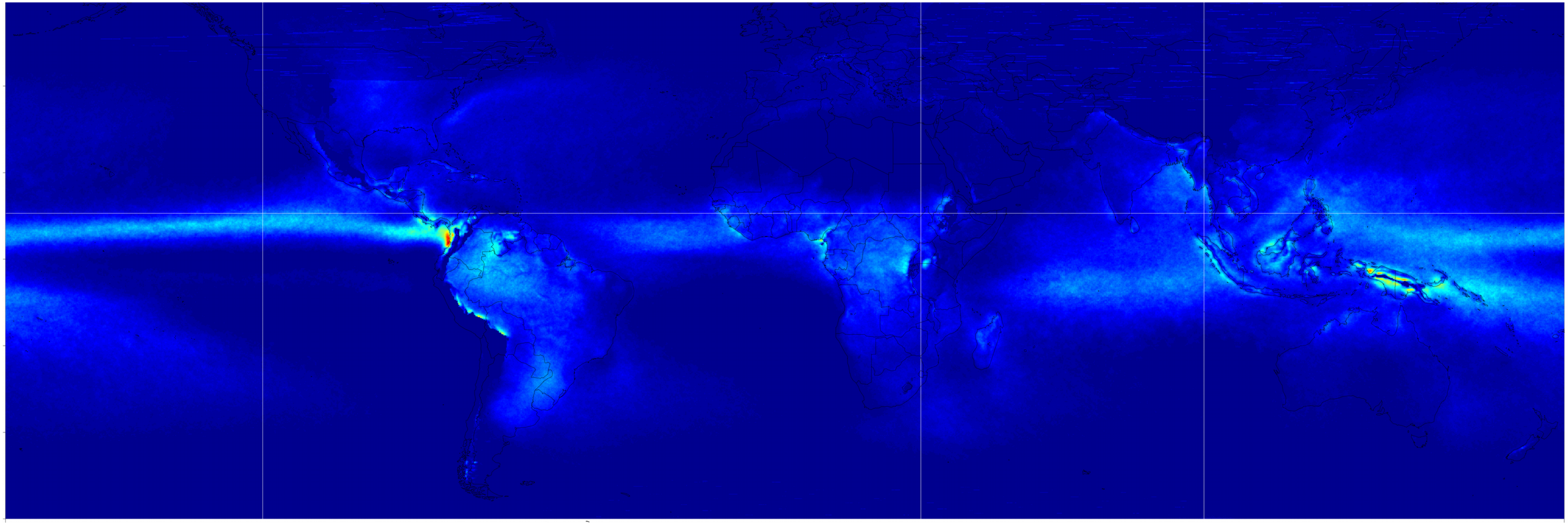
→ Some problems are not documented



Brightness temperature of windows channel 1 of AMSU-B

First climatology of Deep Convection and Convective Overshooting

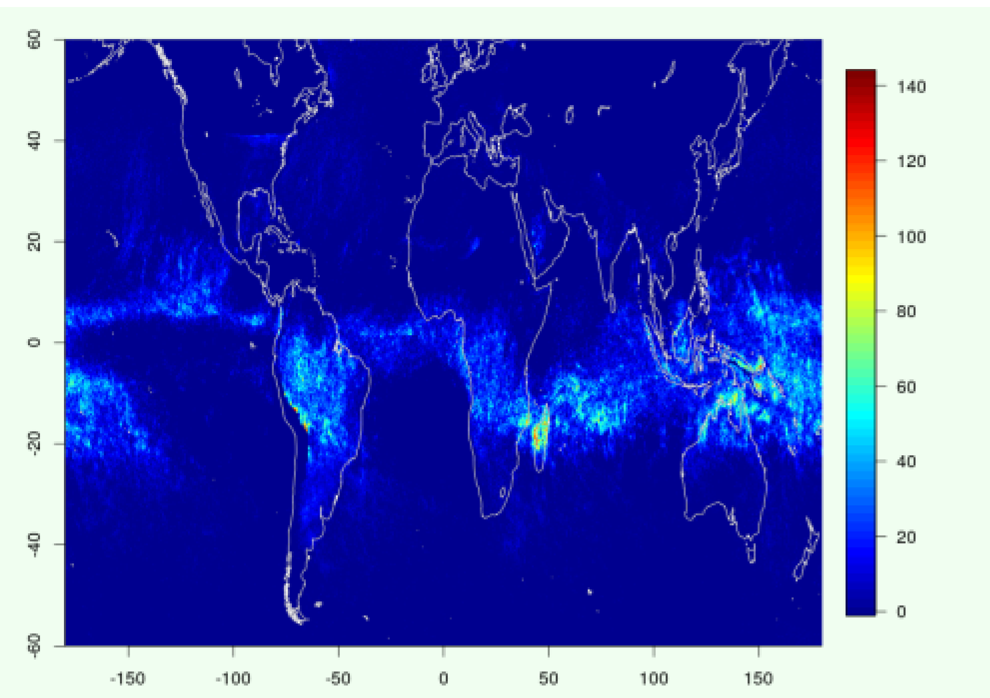
- Range: 60°S/60°N
- Daily resolution
- 0.2°x 0.2° resolution



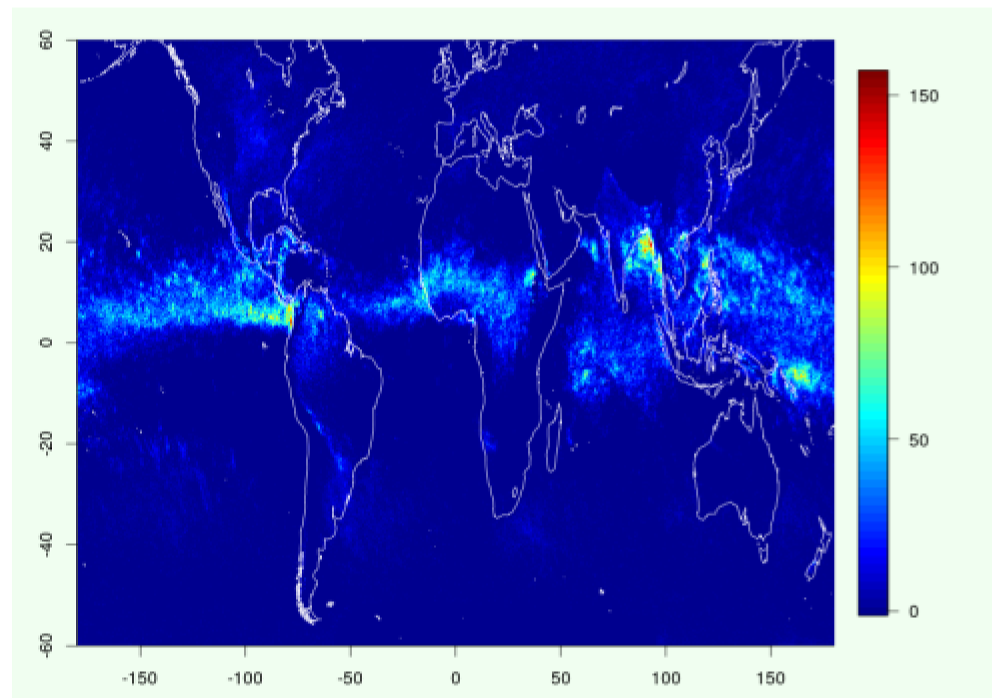
DC occurrence between 1999 and 2015

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

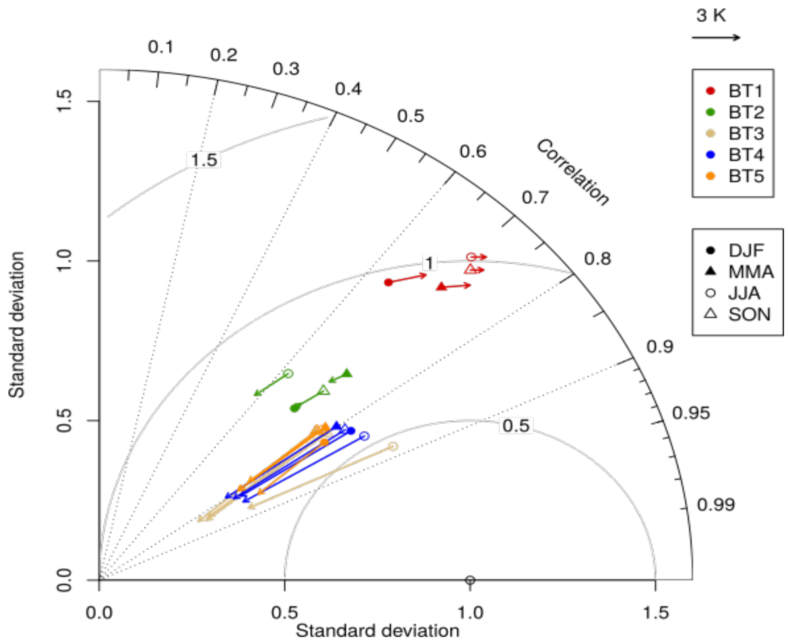
=> Passive microwave radiometers can be used to monitor convection from 60°S/60°N except in mountainous and frozen soil regions

• 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)

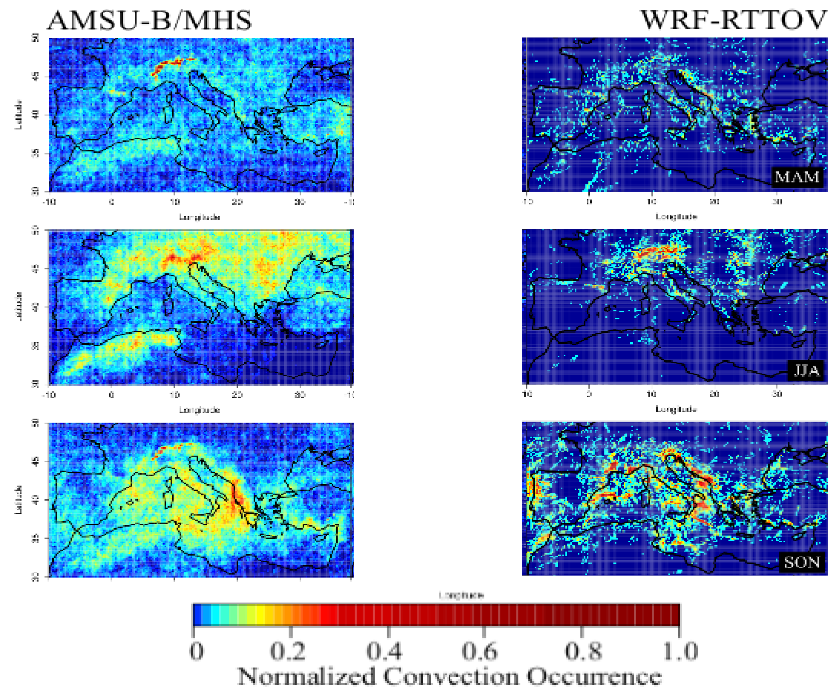
Model evaluation using DC climatology

- 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