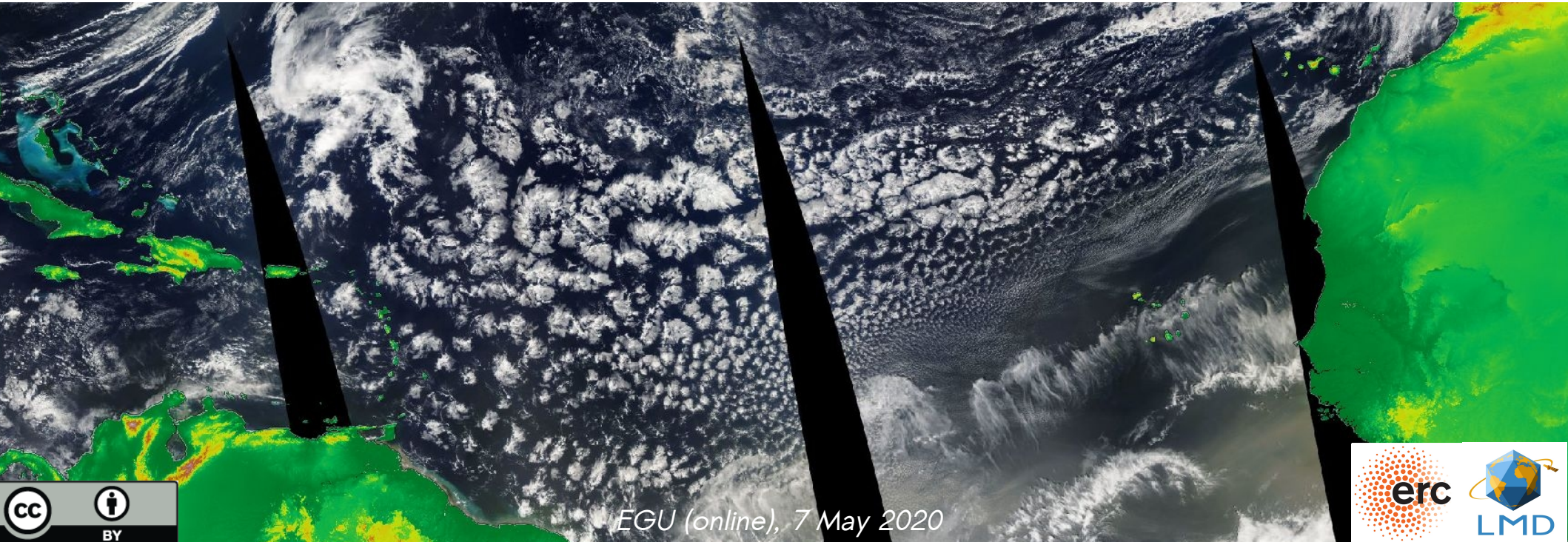
Dependence of Mesoscale Patterns of Trade-wind Clouds on Environmental Conditions : An Investigation using Satellite and In-Situ Observations

Sandrine Bony[1], Hauke Schulz[2], Jessica Vial[1] and Bjorn Stevens[2]

[1]LMD/IPSL, Sorbonne University, Paris, France

[2]Max Planck Institute for Meteorology, Hamburg, Germany



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Sugar, Gravel, Fish & Flowers : four prominents patterns of tradewind clouds

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RESEARCH ARTICLE

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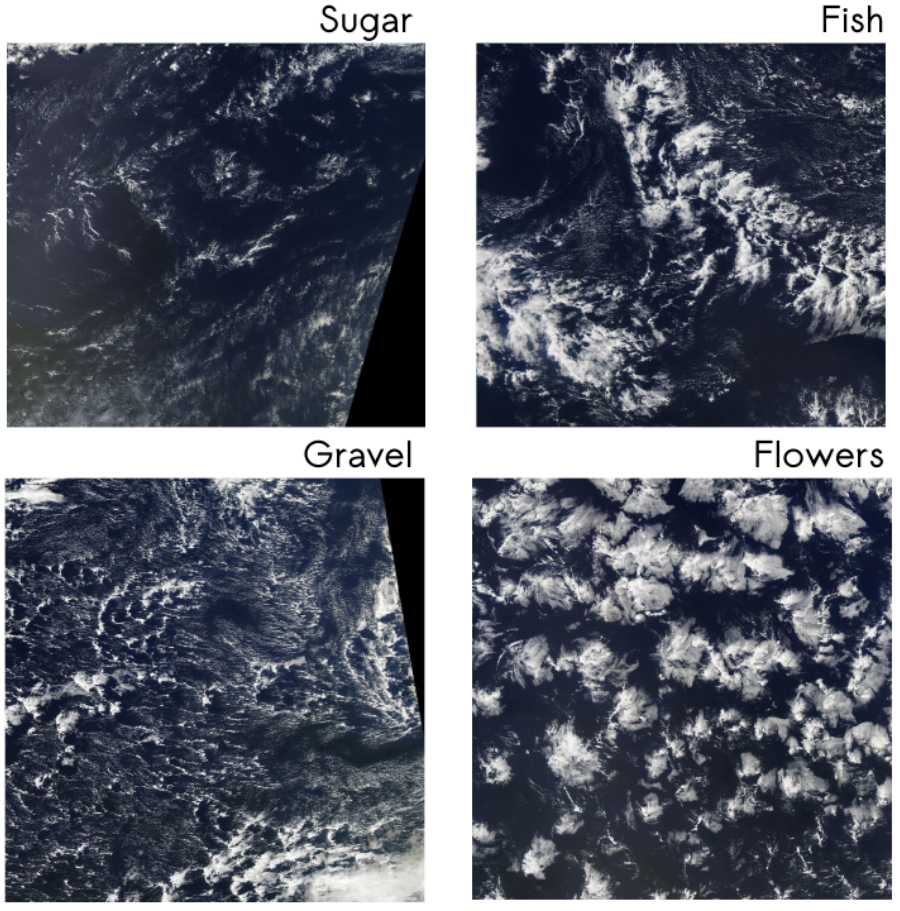
Sugar, gravel, fish and flowers: Mesoscale cloud patterns in the trade winds

Bjorn Stevens[1] | Sandrine Bony[2] | Hélène Brogniez[3] | Laureline Hentgen[4] | Cathy Hohenegger[1] | Christoph Kiemle[5] | Tristan S. L'Ecuyer[6] | Ann Kristin Naumann[1] | Hauke Schulz[1] | Pier A. Siebesma[7] | Jessica Vial[2] | Dave M. Winker[8] | Paquita Zuidema[9]

→ *Based on a visual classification of cloud patterns*

→ *Can these patterns be defined in a more automated fashion?*

- *machine learning (e.g. Denby 2020, Rasp et al. 2020)*
- *simple analysis of the Tb field derived from satellite*
  Bony, Schulz, Vial and Stevens, GRL, 2020
  https://doi.org/10.1029/2019GL085988

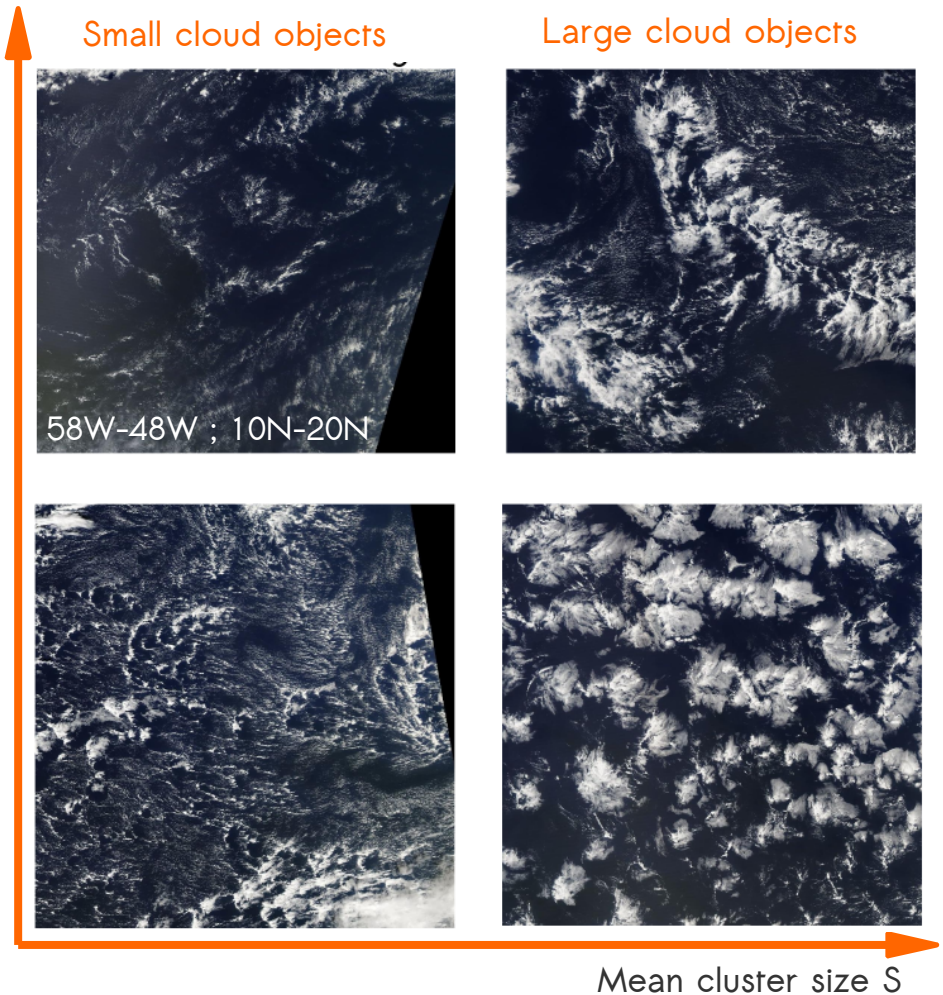


Characterization of convective organization patterns using Tb

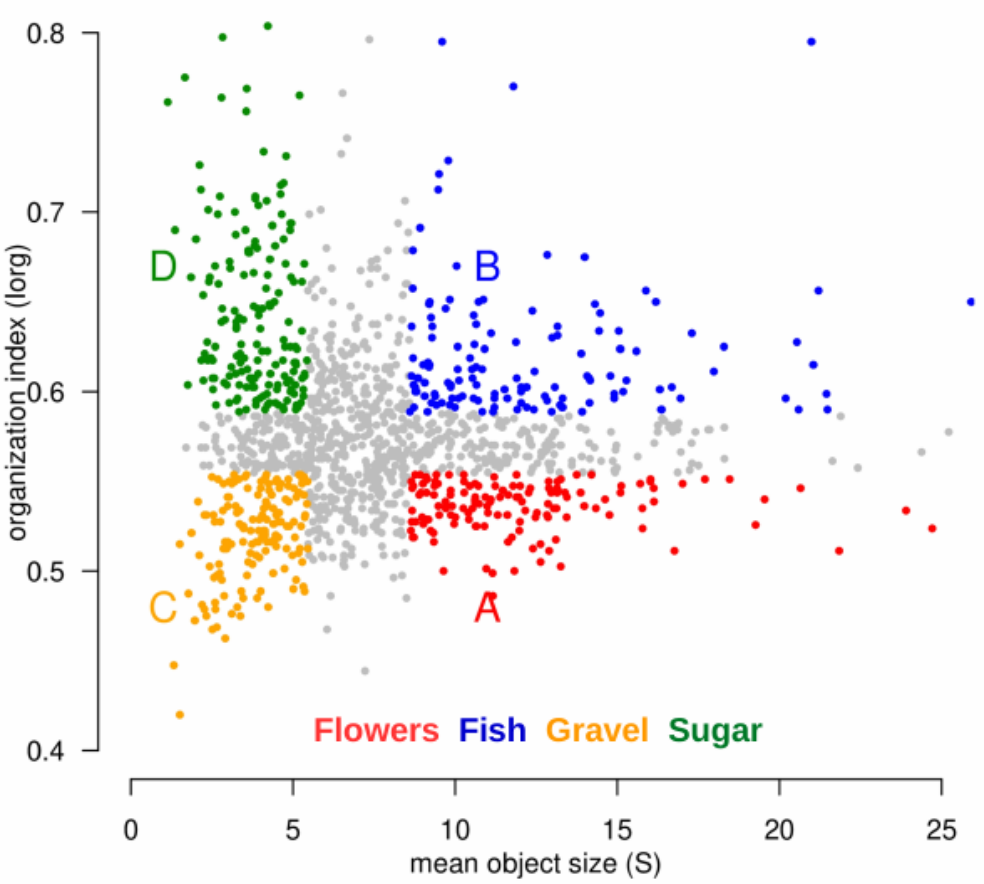
Geostationnary
(GridSat-B1,8km) & MODIS (1km)
satellite data during
2000-2019 (DJF)
+
Cloud objects :
280K < Tb < 290K
+
Nearest-neighbor segmentation
→ centroids, area
+
2 metrics : S, Iorg
+
4 classes defined by terciles
of S and Iorg

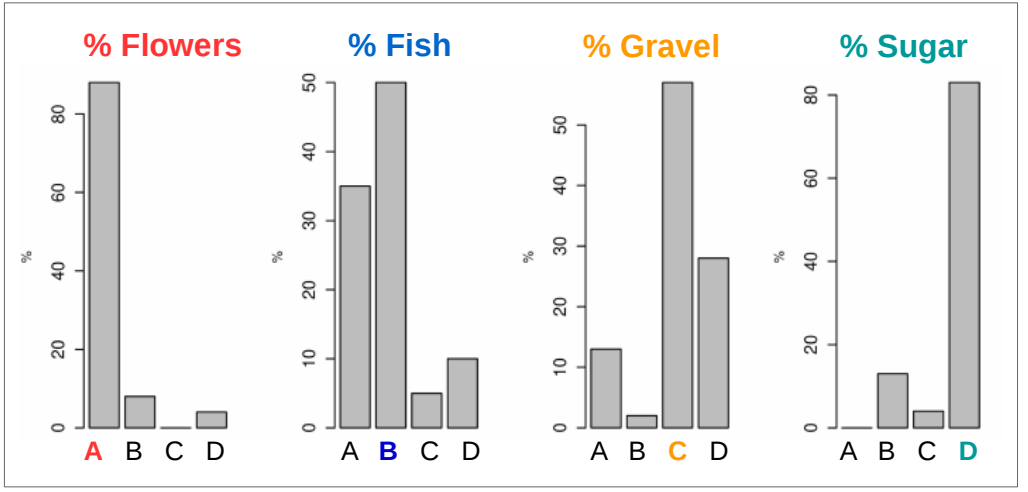
Convective organization
index Iorg
(after Tompkins and Semie
2017, Weger et al. 1992)

Random to regular
distribution of cloud
centroids



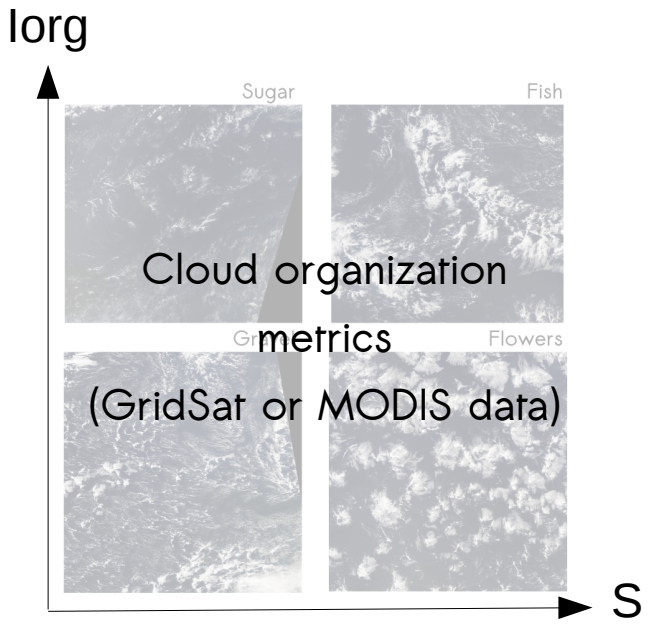
Characterization of convective organization patterns using Tb

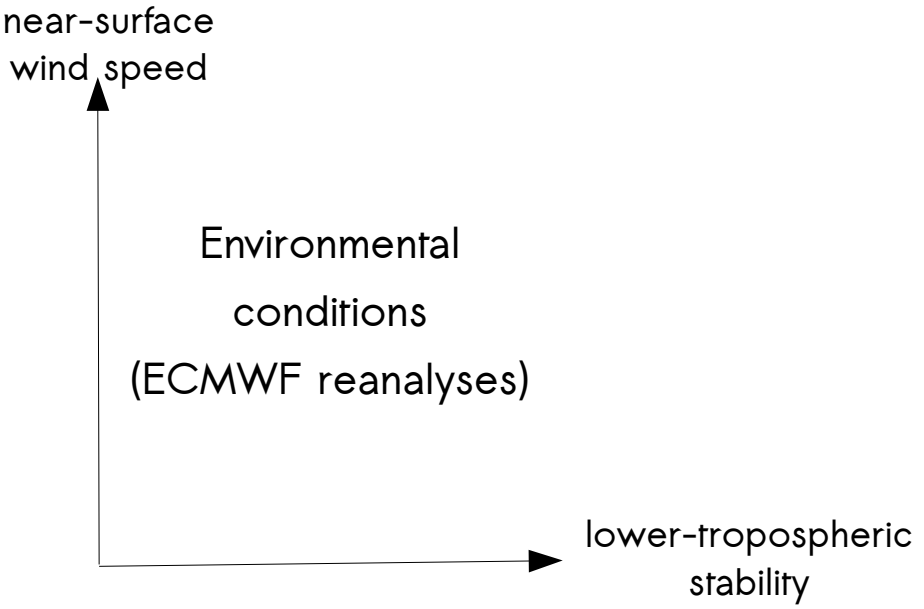




The good correspondence between (S, lorg) classes and visually-classified cloud patterns allows us to associate each class of (S, lorg) to one of the four prominent mesoscale cloud patterns

Relationship between cloud patterns and environmental conditions

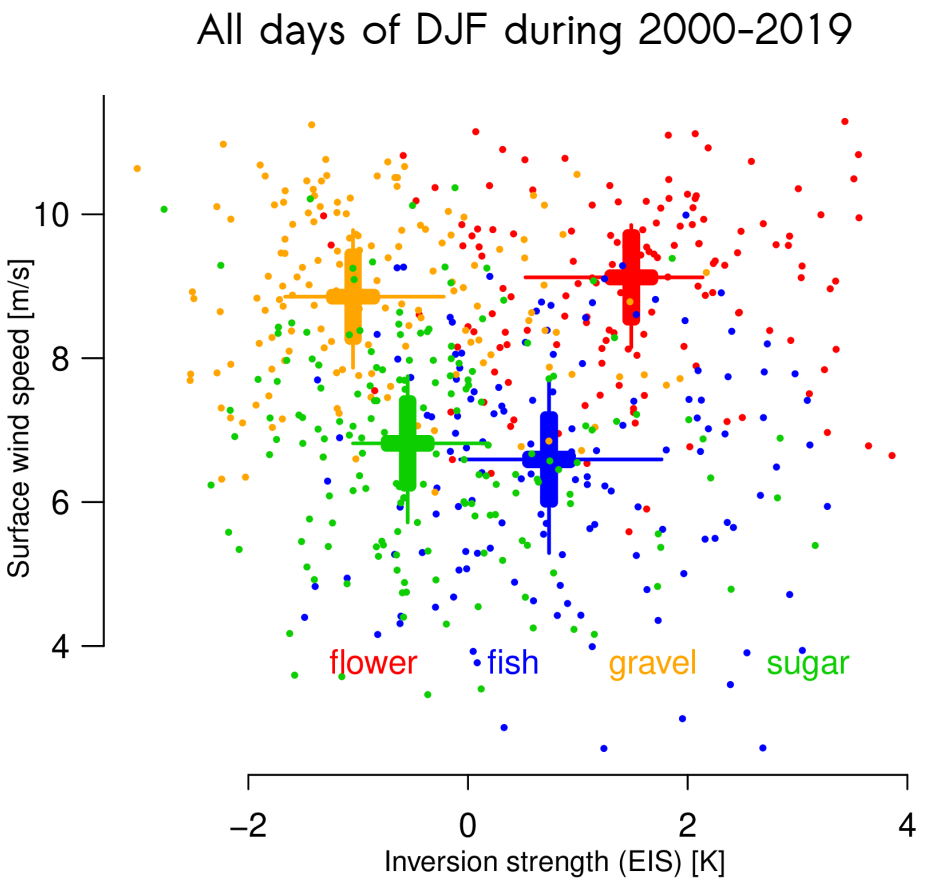


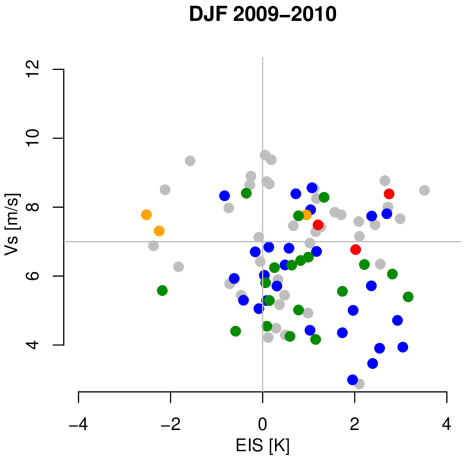


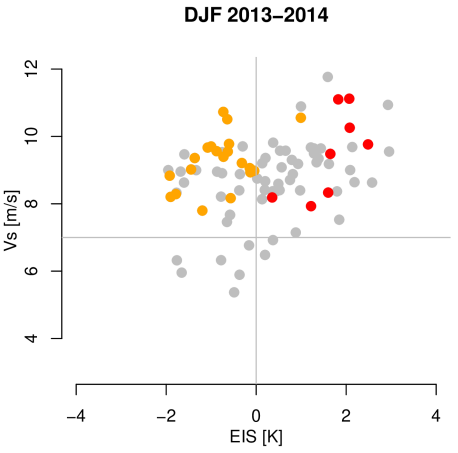
Considered : SST, lower-tropospheric stability (EIS or LTS), surface wind, wind shear, free tropospheric humidiy, large-scale vertical motion, etc

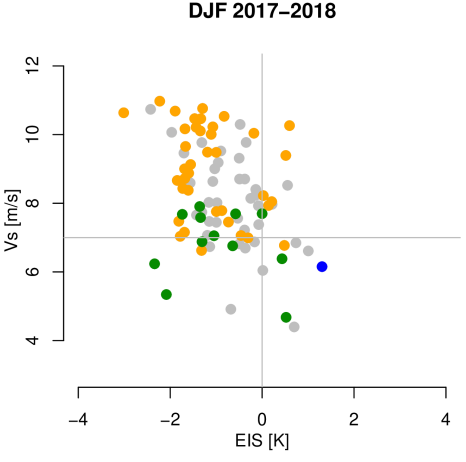
Two timescales : day-to-day variatons, interannual variations

Relationship between cloud patterns and environmental conditions



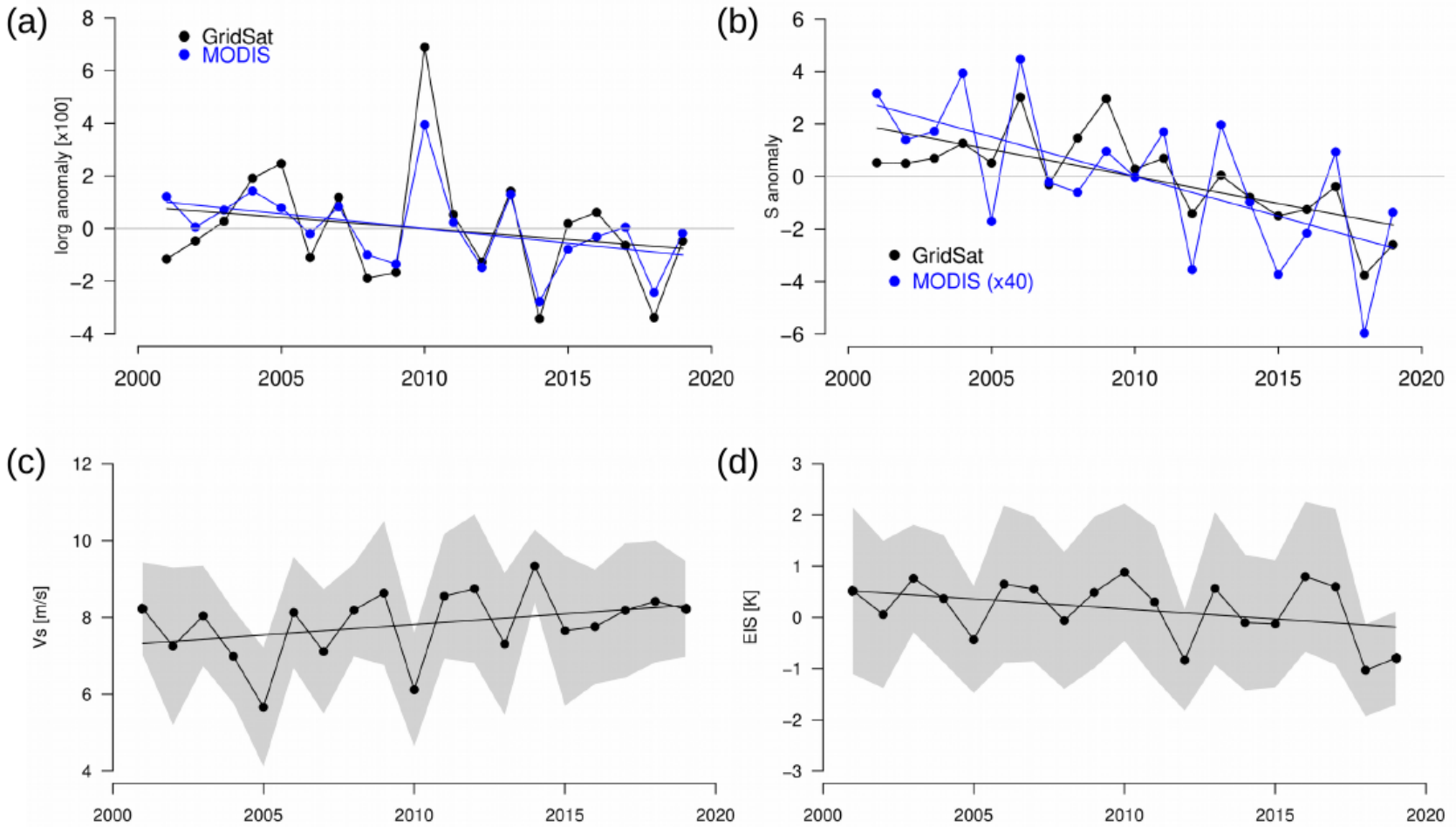




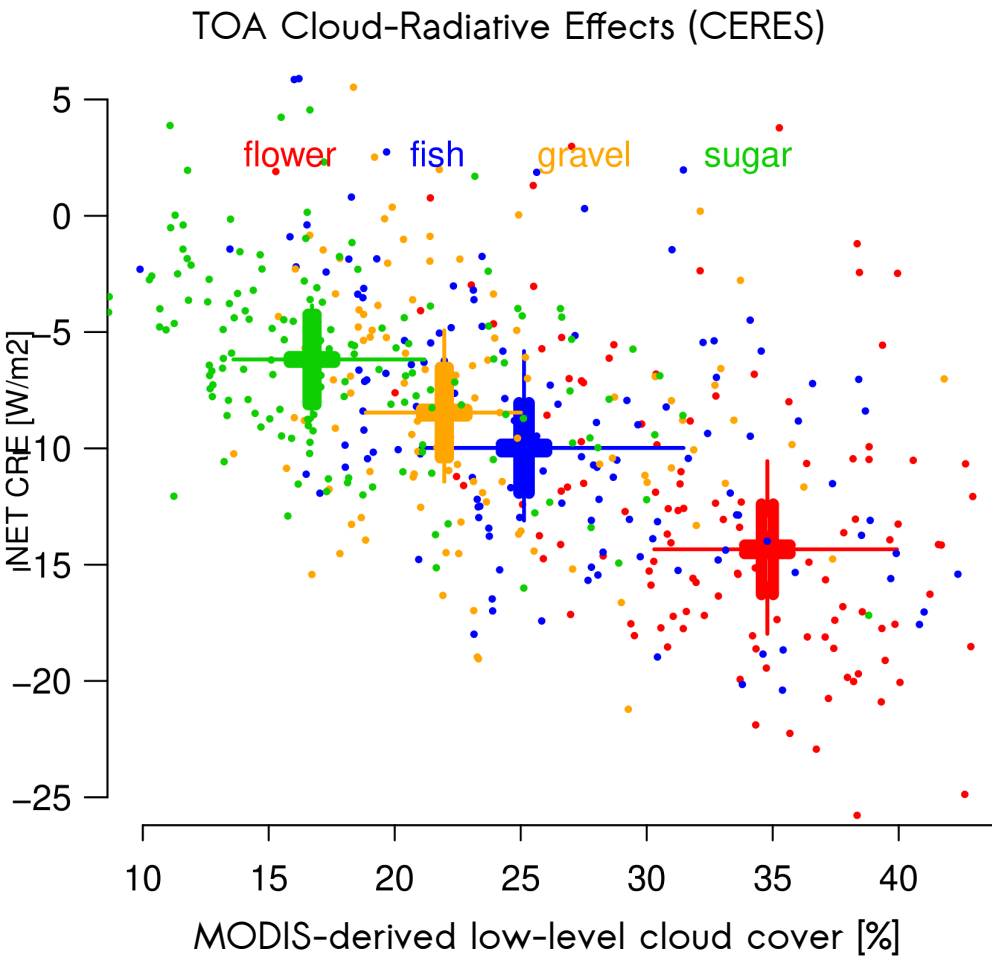


Note : consistent results are obtained when using MODIS-IR data (1 km, twice daily) or GOES16-IR data (2 km, 3-hourly) data to classify the mesoscale cloud patterns (Bony et al. GRL 2020)

Interannual variations of aggregation indices & link to environment



Radiative impact of cloud mesoscale patterns



→ The low-cloud amount varies by a factor of two across the different patterns

→ Changes in mesoscale organization affect the Earth's radiation budget primarily through changes in the low-cloud amount

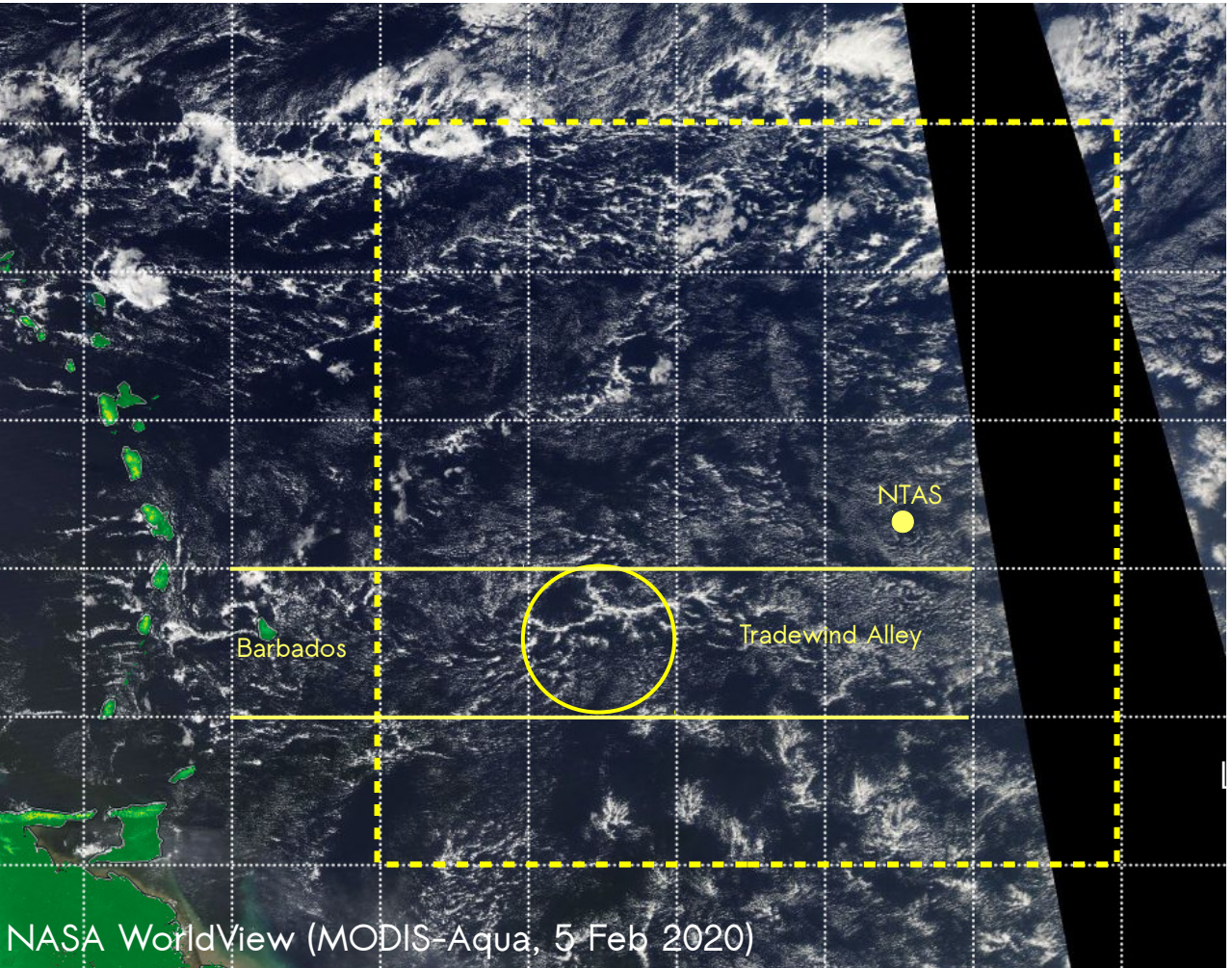
Mechanisms underlying the mesoscale organization of tradewind clouds ?
Importance of the convective organization for cloud properties ?
Relevance for climate change cloud feedbacks ?

Hopefully, the EUREC^{4}A field campaign that took place in Barbados on Jan-Feb 2020 will help us advance on these questions.

More information on EUREC4A : http://eurec4a.eu

Bony, Stevens et al. (Surveys in Geophysics, 2017)
Stevens et al. (overview paper in preparation)

EUREC⁴A (Jan - Feb 2020)



By continuity with the previous study, and to assess the representativity of the EUREC4A period (Jan-Feb 2020 vs Dec-Jan-Feb 2000-2019), we characterize the convective cloud organization over the same domain (48-58W,10-20N) and at the daily timescale.

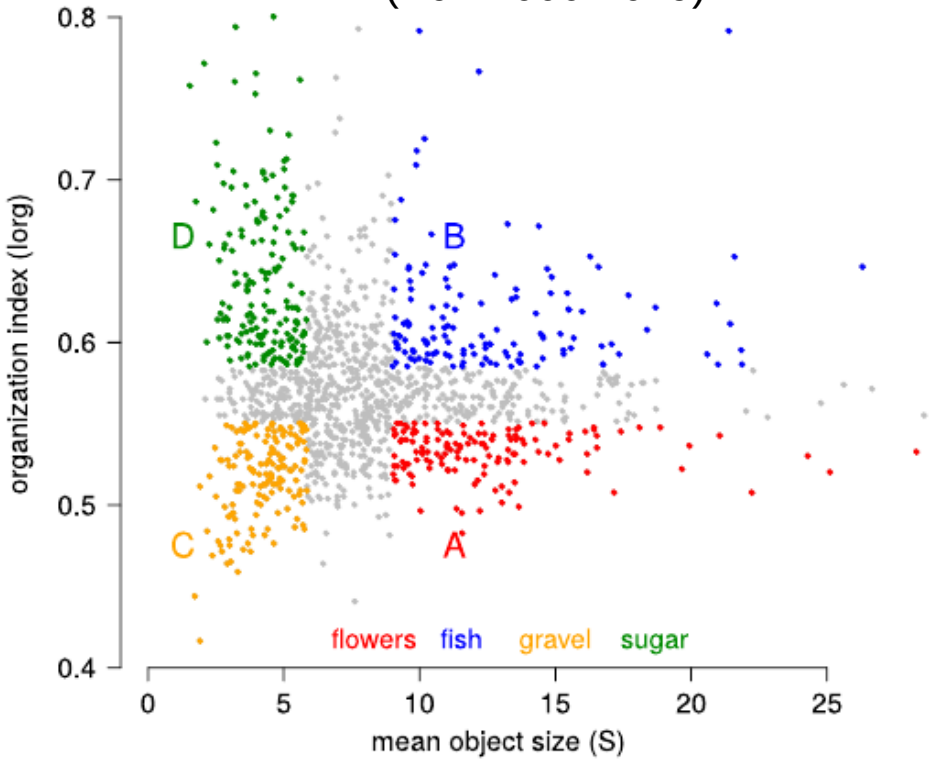
→ Daily organization metrics are computed from half-hourly GOES-16 IR data (2 km resolution), from Jan 1 to Feb 28 2020.

→ As previously, we characterize the organization over the whole domain, which means that we characterize mostly the dominant cloud pattern (as illustrated on the left, several patterns can occur within the domain)

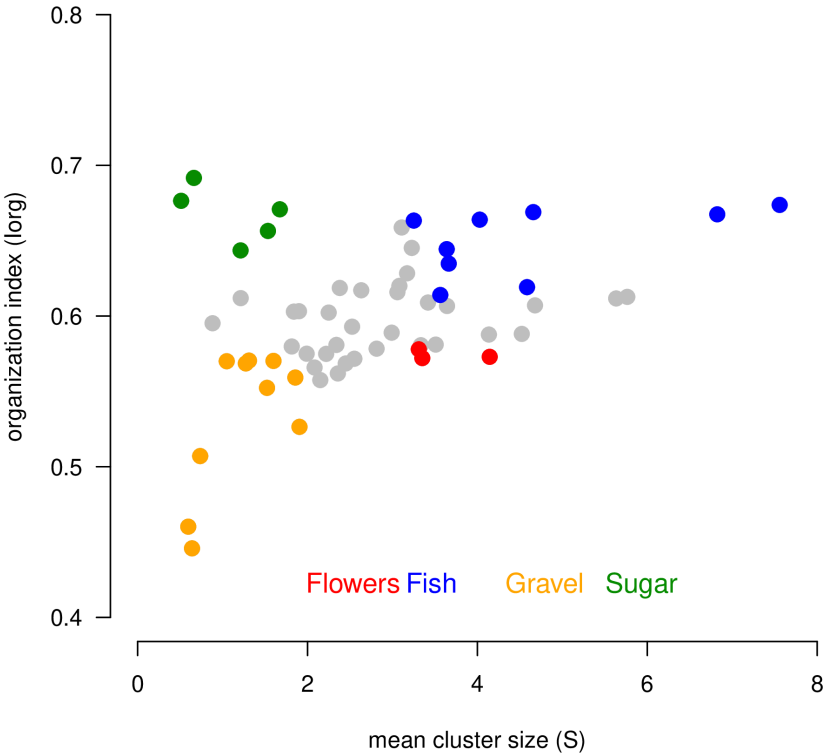
→ Note that this domain is larger than the area of EUREC⁴A operations.

EUREC⁴A : Mesoscale cloud patterns

ERA interim & GridSat ; daily means
(DJF 2000-2019)

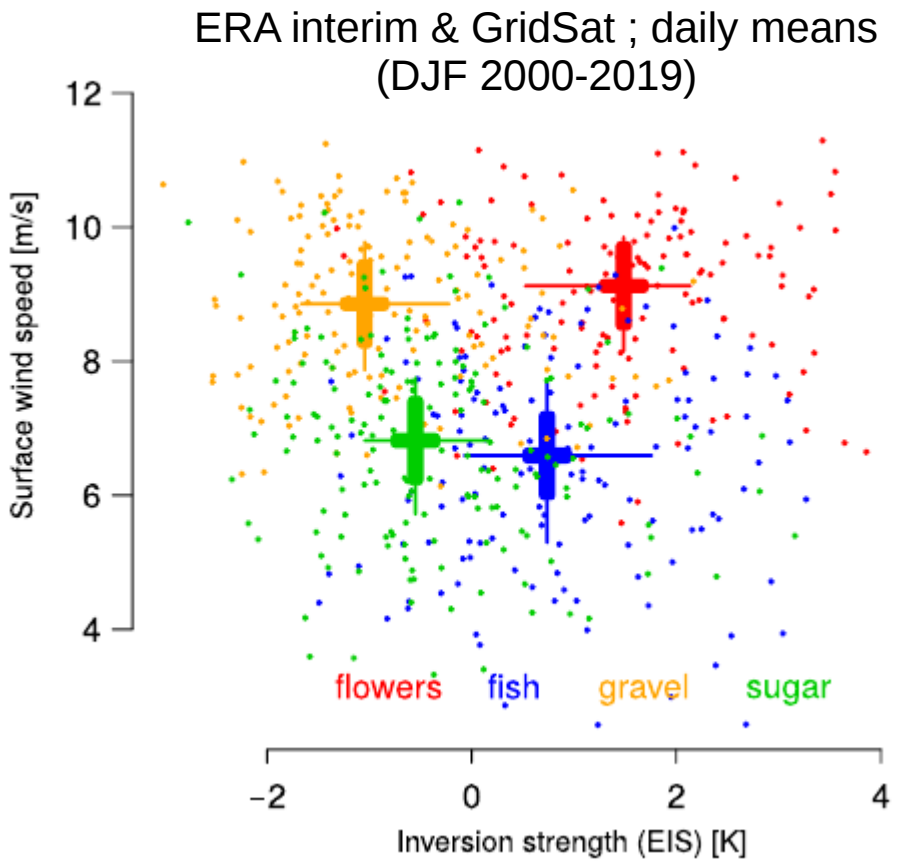


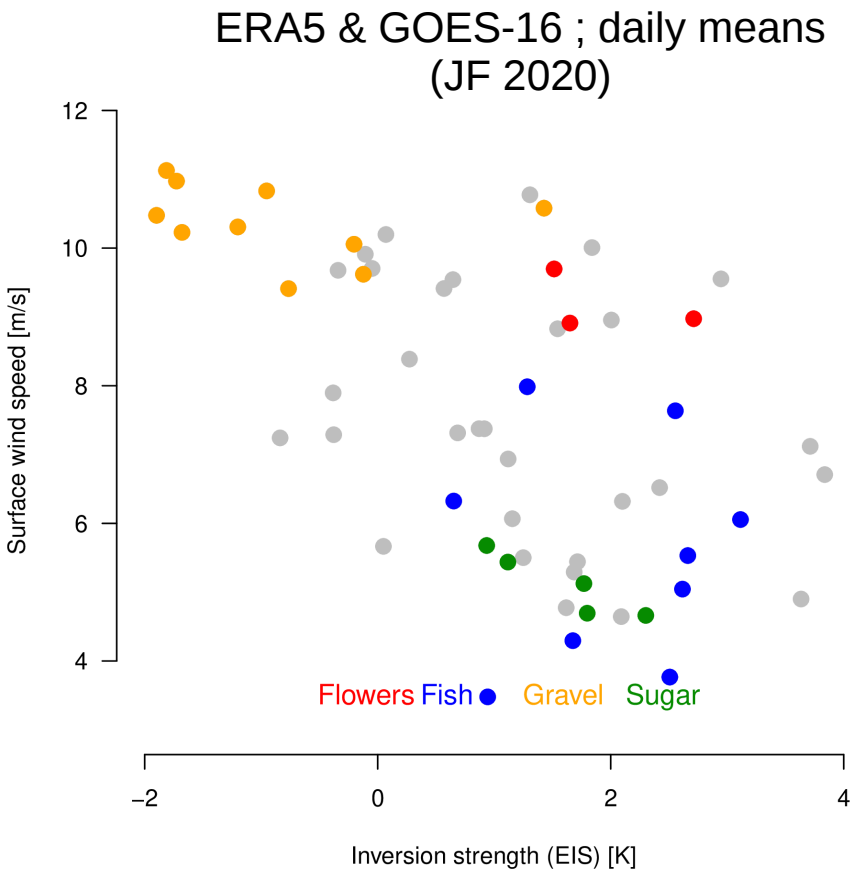
ERA5 & GOES-16 ; daily means
(JF 2020)



Rq : GridSat and GOES-16 have different resolutions (7 km vs 2 km) → absolute values of (S, lorg) differ but the classification into classes (A/B/C/D...or Flowers/Fish/Gravel/Sugar) does not depend on absolute values of S or lorg.

EUREC⁴A : Link between mesoscale cloud patterns and environment

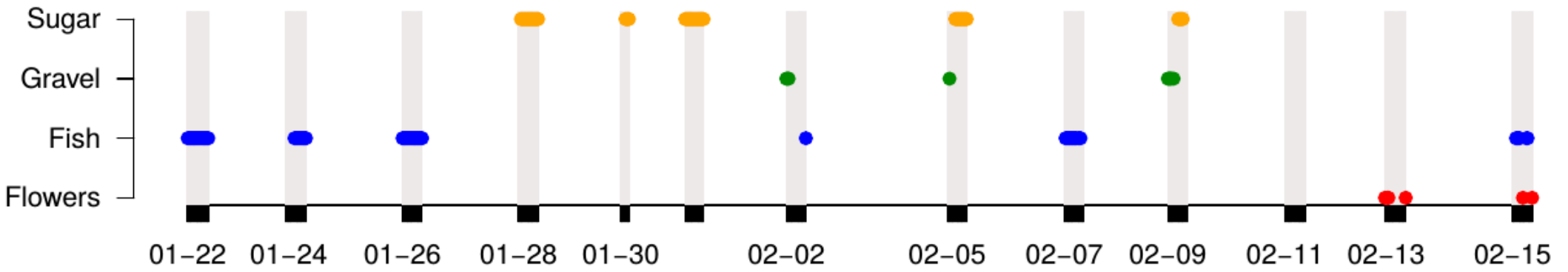


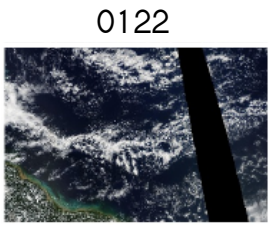


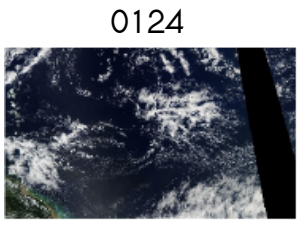
Rq : GridSat and GOES-16 have different resolutions (7 km vs 2 km) → absolute values of (S, lorg) differ but the classification into classes (A/B/C/D...or Flowers/Fish/Gravel/Sugar) does not depend on absolute values of S or lorg.

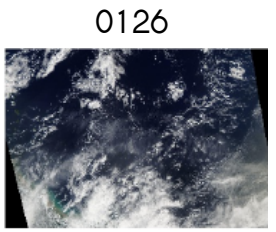
EUREC⁴A : Patterns on days with coordinated flights (preliminary results)

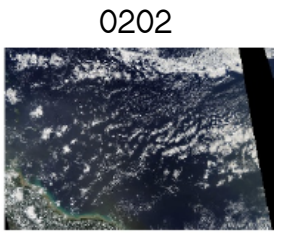
Rq : here patterns are determined every 30 min, over (58W-48W, 10N-20N)

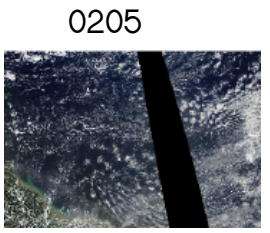


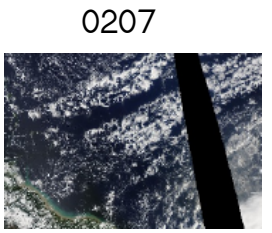


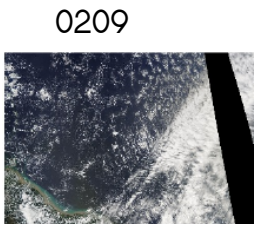


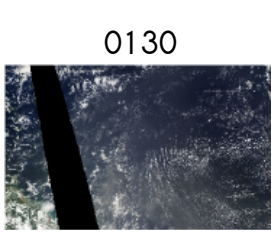


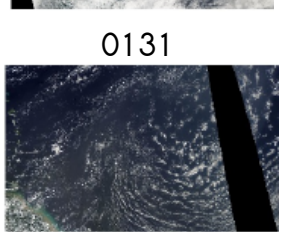


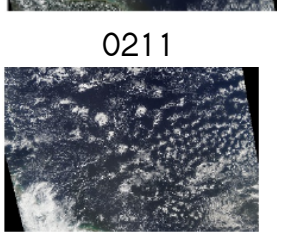


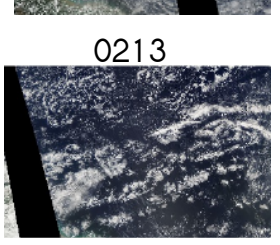


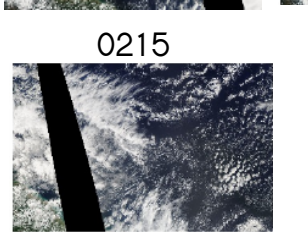












Conclusions

- A methodology has been developed to recognize prominent patterns of shallow convection (Flowers, Fish, Gravel, Sugar) from satellite observations of brightness temperature.
- Mesoscale patterns exhibit strong relationships with surface wind speed and lower-tropospheric stability.
- Owing to their differences in low-cloud fraction, mesoscale patterns exert different impacts on TOA radiation.
- More information in: *Bony, Schulz, Vial and Stevens (GRL, 2020)*

EUREC^{4}A vs climatology:

- The relationship between mesoscale patterns of convection and environmental conditions during EUREC4A is consistent, at first order, with the relationships found during the last 20 years. But we missed situations of (low wind speed, weak lower-tropospheric stability).
- Situations favourable to *Gravel* patterns (strong wind speed, weak stability) occurred mostly before Jan 15.
- Environmental conditions are less discriminating of the *Sugar* pattern than of other patterns.

Next :

- Characterization of the patterns (and their environment) on smaller domains, and shorter timescales
- Exploration of the mechanisms underlying the different patterns of organization