Relating MSG Rain over the Tropical Atlantic with ASCAT derived surface DIV and VORT

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Downbursts trigger new convection

- The disbursing cool dry air can create an outflow boundary around the system called a gust front made up of the strongest, most damaging winds.

- Can form a shelf cloud on top of gust front that can produce lighter precipitation.

When the cool air from the downdraft reaches the surface,...

... it creates the outflow which pushes forward and provides lift for clouds to form (along the black line).
Motivation

- NWP often too coarse resolution to resolve downbursts
- Inaccurate modelling of the air-sea interaction leads to less accurate modelling of convective storms

Aim of the project

- Investigate the dynamics associated with rain events in Mesoscale Convective Systems (MCS) in the Tropical Atlantic
- using collocated ASCAT-A, ASCAT-B and Meteosat MSG Rain

Methods

- Surface divergence, vorticity, singularity exponents
Data available every 15 minutes from VIS and INFRA imager

Liquid water equivalent of precipitation
June 2013 (82 collocations)

In tropics, ASCAT-A & B are 50 minutes apart and swaths partially overlap.

\[ \text{DIV} > 3 \times 10^{-4} \text{ s}^{-1} \]

\[ \text{DIV} < -3 \times 10^{-4} \text{ s}^{-1} \]
Information used in methods to estimate DIV and VORT

First Diffs

Central Diffs

50x50km Greens Thm
PDFs of DIV and VORT

ASCAT-A

DIV

VORT

ECMWF
PDFs of DIV and VORT

**DIV**

ASCAT-A (obs) 2013–06

- First Diff
- Central Diff
- Green thm 50x50 km

**VORT**

ASCAT-A (obs) 2013–06

- First Diff
- Central Diff
- Green thm 50x50 km

**2DVAR**

Not what Marcos showed
3 minute snapshots

Results for Central Differences

DIV

VORT
Singularity Exponents

\[ \min(\text{SE}_u, \text{SE}_v, \text{SE}_{\text{MLE}}) \]

ASCAT-B

SE spectrum

ASCAT-A

50 minutes later

ASCAT-A
NOTE Left-Right SIMILARITY

\[
\min(\text{SE}_u, \text{SE}_v, \text{SE}_{\text{MLE}})
\]
ASCAT-B
Nearest-in-time at k = 7

Animation of 17 frames of MSG (15 minutes apart)

ASCAT-A
Nearest-in-time at k = 10

Contours SE = -0.1
What is inside the black box called Singularity Analysis?

- Generalization of Taylor expansion to neighborhood of a singularity

\[
\frac{1}{r} |s(\vec{x} + \vec{r}) - s(\vec{x})| \sim r^h(\vec{x})
\]

\[
\|\nabla s\|(\vec{x}, r) \sim r^h(\vec{x})
\]

\(h > 0.1 \implies \text{locally regular/smooth}\)

\(h < -0.1 \implies \text{locally rough/spiky}\)

\text{i.e., steep gradients / jumps have } h < -0.1
inside the SA black box...

\[ s \rightarrow \tilde{s} \rightarrow \tilde{u} \]

\[ \tilde{u} = (u, v) \]

\[ \| \nabla \tilde{u} \|(\vec{x}, r) = \left| \begin{array}{cc} \frac{\partial u}{\partial x} & \frac{\partial v}{\partial x} \\ \frac{\partial u}{\partial y} & \frac{\partial v}{\partial y} \end{array} \right| \]

\[ \| \nabla \tilde{u} \|^2 = \| \partial_x u \|^2 + \| \partial_y v \|^2 \]

\[ + \| \partial_y u \|^2 + \| \partial_x v \|^2 \]

DIV

VORT

SEs for

\[ s = u, s = v, \text{ and } s = (u, v) \]

mix DIV and VORT info
\min(SE_u, SE_v, SE_{MLE})
Can retain info about the sign of DIV and VORT in the Singularity Exponent

**SE_DIV**
- DIV > 0
- DIV < 0

**SE_VORT**
- VORT > 0
- VORT < 0
MSG Rain and Singularity Exponents strongly correlated.

Singularity Exponents:
- DIV (+/-),
- VORT (+/-),
- and QC

Future:
- Quantify how DIV and VORT vary in between ASCAT-A and B passes
- Want to relate this with what is going on up top (how to make it quantitative?).
Speculation:

- Can Singularity Exponents be useful in Tropical Cyclone monitoring?  
  \textit{(We believe so.)}
Apply KNMI QC flag

Apply KNMI and 2DVAR QC flags