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Inferring High Ice Water Content from the Geostationary Satellite data

HAIC/HIWC meeting, Toronto, 16-18 May 2016

HAIC – High Altitude Ice Crystals

Content

Special thanks to

E. Defer, F. Parole, J. Delanoe, J.-M. Moisselin, A. Gounou, S. Turner, F. Dezitter, A. Camels.

Contents

- MSG-CPP High Ice Water Content “mask” (geostationary SEVIRI)
- Product evaluation with other satellite data
- Field campaign results (Cayenne 2015, A340 2016/Darwin)
- Conclusions, outlook

HAIC satellite measurements

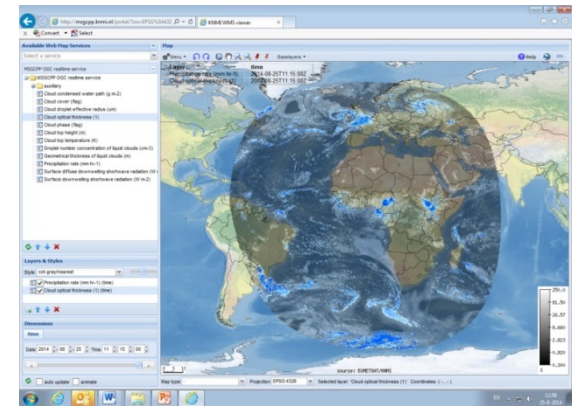
Workpackage SP3: detection of icing conditions using satellite measurements

SP 3.2: detection of high ice water content (HIWC) situations derived from geostationary satellite imagers, in particular the MSG-SEVIRI (**M**eteosat **S**econd **G**eneration).

KNMI's **C**loud **P**hysical **P**arameter (**CPP**) retrieval algorithm

CPP provides information on cloud physical properties from the geostationary SEVIRI instrument on board of METEOSAT 8/9/10.

- daytime only (needs visible radiation)
- overpass every 15 minutes
- passive sensor



MSG-CPP products

ID	Product	Unit	Accuracy
CLDMASK	Cloud Fraction	[-]	0.1
CPH	Cloud Thermodynamic Phase (ice or water)	[-]	0.1
COT	Cloud Optical Thickness	[-]	15%
REFF	Effective particle size	[m]	-
CTT	Cloud Top Temperature	[K]	5 K
CTH	Cloud Top Height	[m]	-
DCLD*	Geometrical Cloud Depth	[m]	250 m
DnDv*	Droplet Number Concentration	[m ⁻³]	-
CWP**	Condensed Water Path	[kg m ⁻²]	15 x 10 ⁻³ kg m ⁻²

Table 1: List of MSG Cloud Physical Products and their reported validation accuracies

***):** These products are only retrieved for liquid water clouds

****):** Note, this is a combined product. The CWP for liquid water clouds represents the Liquid Water Path, CWP for ice clouds represents the Ice Water Path.

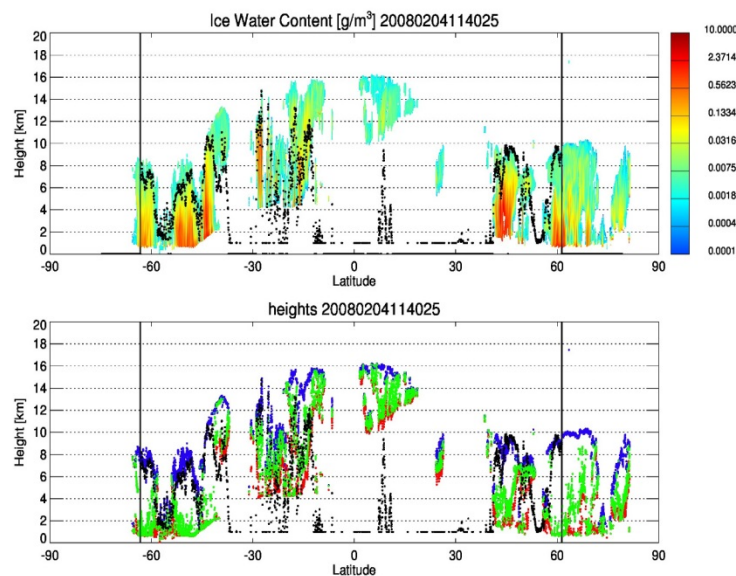
Updated MSG-CPP HIWC mask

Goal: MSG-CPP conditions for **DARDAR High IWC** = > 1.0 g/m^3 (that is a motivated *choice*)
High IWC threshold exceeded anywhere in the vertical profile.

- Use approximately 25 DARDAR (CloudSat + Calipso) orbits in 2008, two per month.

DARDAR-based MSG-CPP High IWC mask

1. The cloud phase ice
2. Condensed water path > 100 g/m^2
3. Cloud top temperature < 270 K
4. Cloud optical thickness > 20

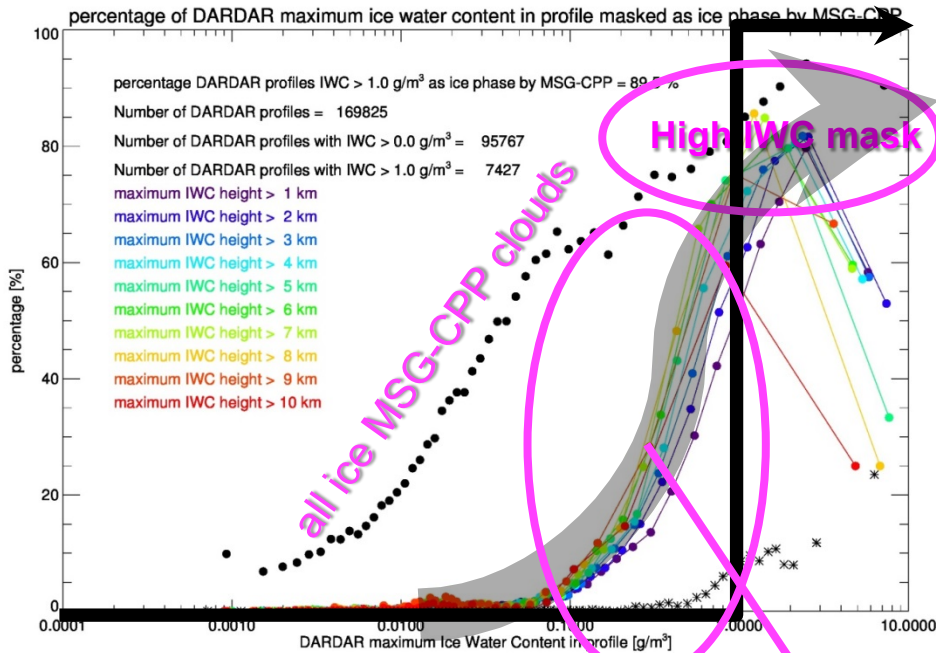


For more information, a paper is ready for submission [de Laat et al., 2016]

(waiting for dissemination approval from the HAIC consortium)

Rate of Detection & False Alarms

Rate of Detection



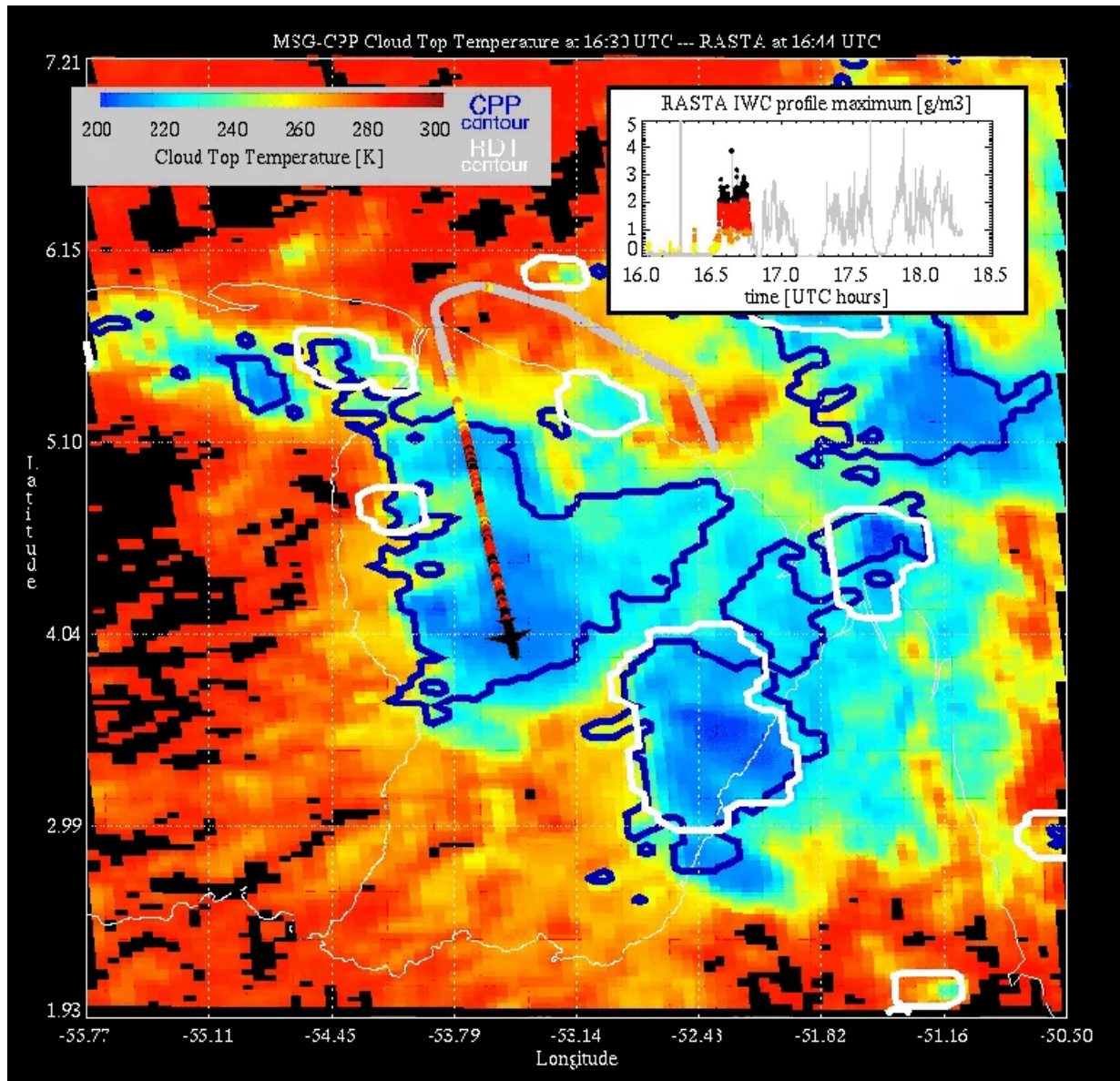
DARDAR Ice Water Content
(logarithmic scale)

High IWC mask:

- ~70-80% detection of DARDAR IWC > 1 g/m³
- Overall: > 90% of DARDAR “ice” clouds are rejected
- Fast decrease in (false) detection of IWC < 1 g/m³
- Large majority of “false” detection IWC > 0.1 g/m³
- Trade-off:
more detection IWC > 1 g/m³ = more “falses”

- 0.1 g/m³ < IWC < 1 g/m³ ... false or not ???
- > 98% detection success ...

Cayenne 2015: animation! (15 May 2015, F16)

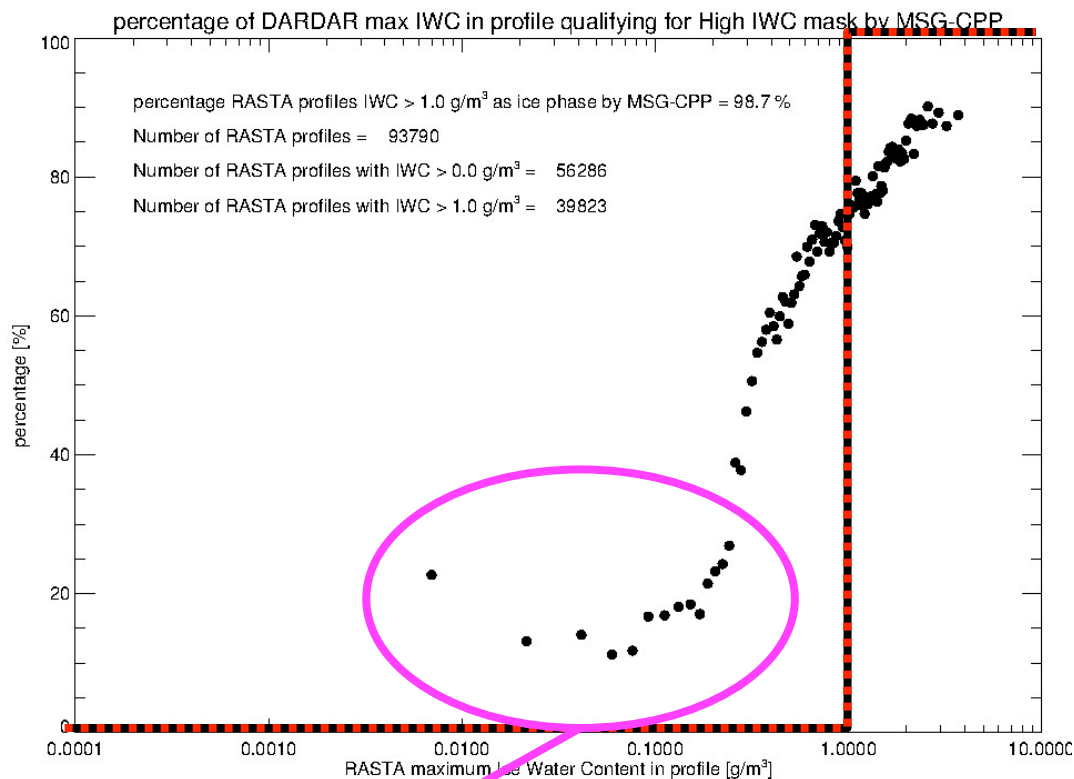
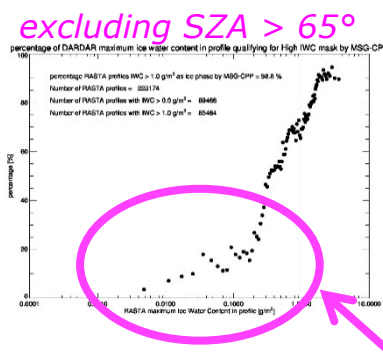
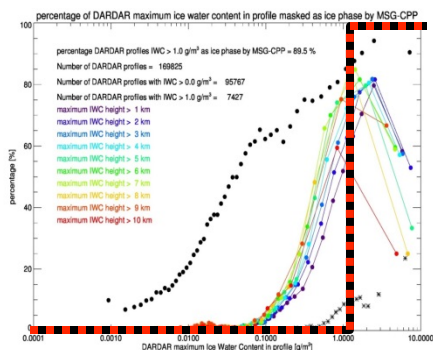


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Cayenne 2015: validation of CPP High IWC mask.

Verification: MSG-CPP High IWC mask detection rate as function of RASTA maximum IWC

RASTA profiles, all 16 flights combined



Solar Zenith Angle/Viewing Angle bias in CPP

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Angle bias in CPP

CASE 1

MSG-CPP HIWC (black) & cloud top temperature

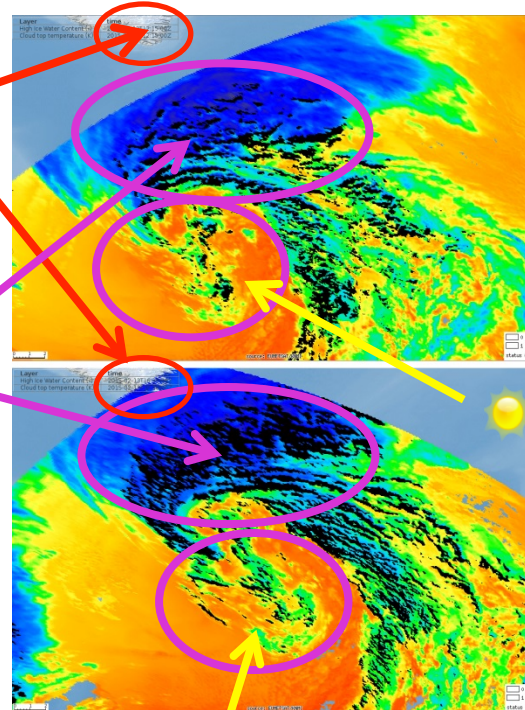
Location: northern Atlantic, south of **Greenland**
 - 13 February 2015
 - Upper panel: 12:15 UTC
 - Lower Panel: 16:30 UTC

HIWC mask at solar/viewing angle geometry of clouds (?), more prominent for lower **SZA** (?)

Possible related to light path and COT ...

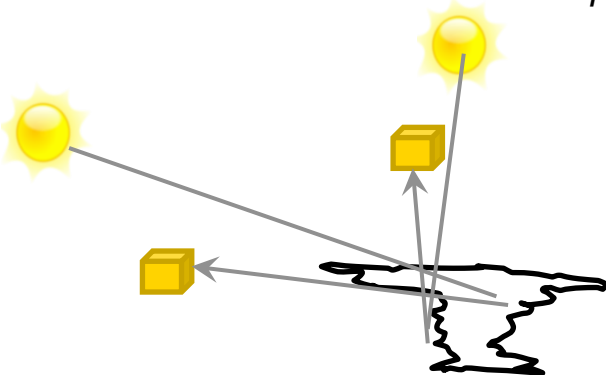
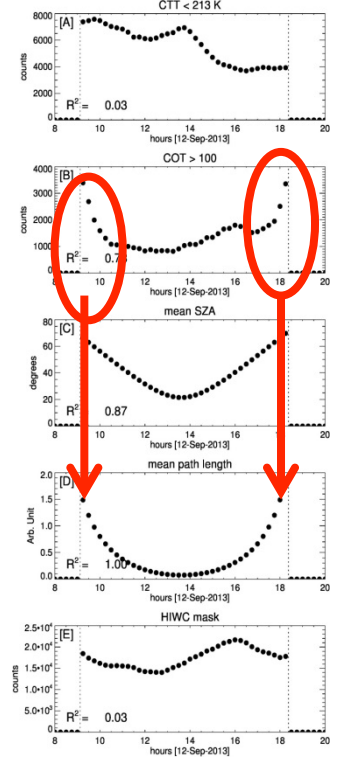
At 12:15 UTC SZA is ~ 75 degrees
 At 16:30 UTC SZA is ~ 55 degrees

Note: sun's location is indicative/approximate



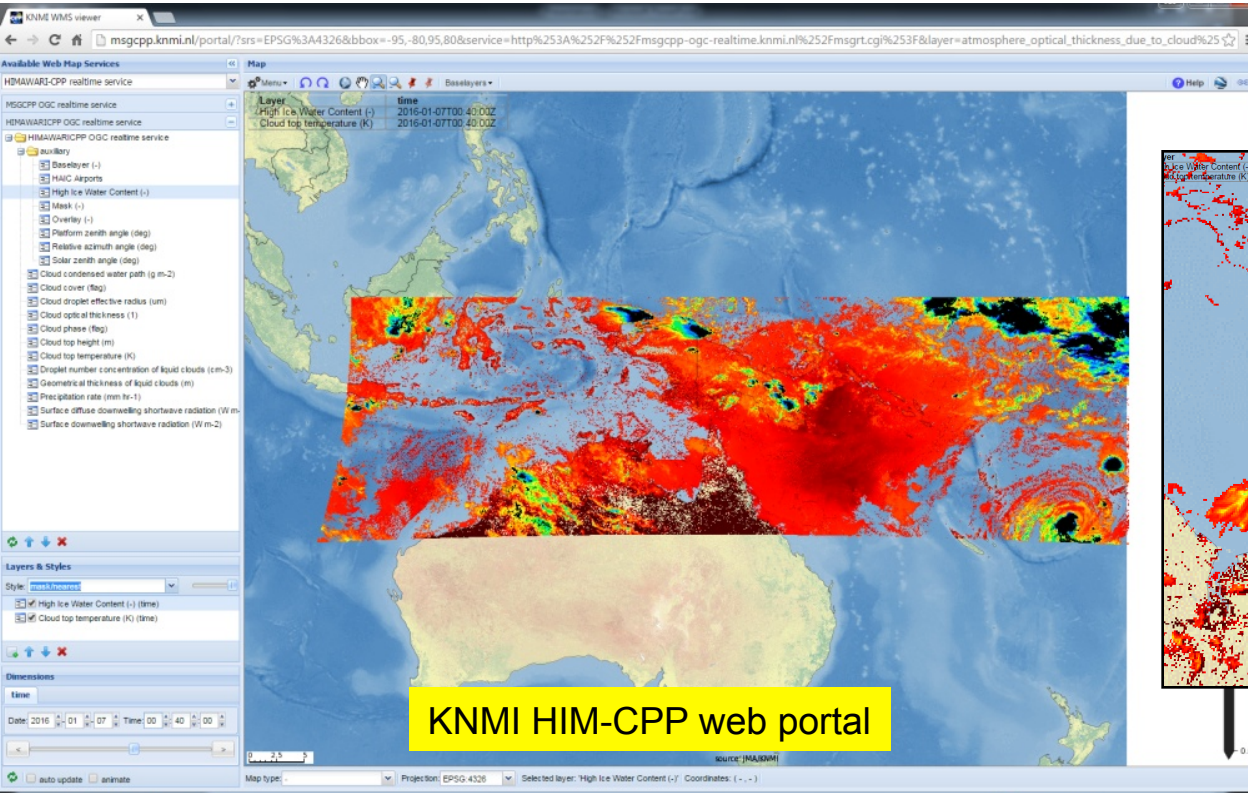
CASE 2

Tropical cyclone analysis

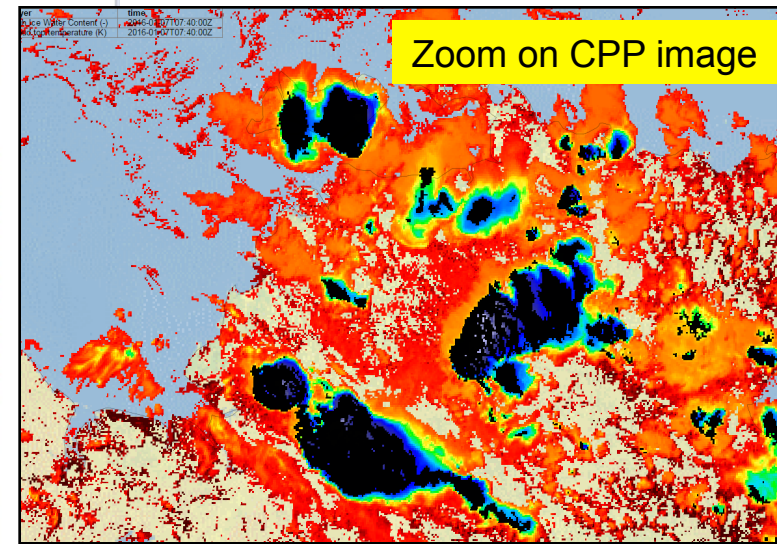


HIM-CPP: support for DARWIN A340 campaign

- Development of dedicated HIM-CPP chain by KNMI (data only public late 2015 by JAXA)
 - ▶ Adaptation and tuning of the CPP algorithms to the HIMAWARI channels
 - ▶ Implementation for real time display via KNMI web portal
 - ▶ Limited area (not full disc) to get fast access to data on ftp-server
 - ▶ Possibly slight bias (e.g. images “too bright” → calibration)

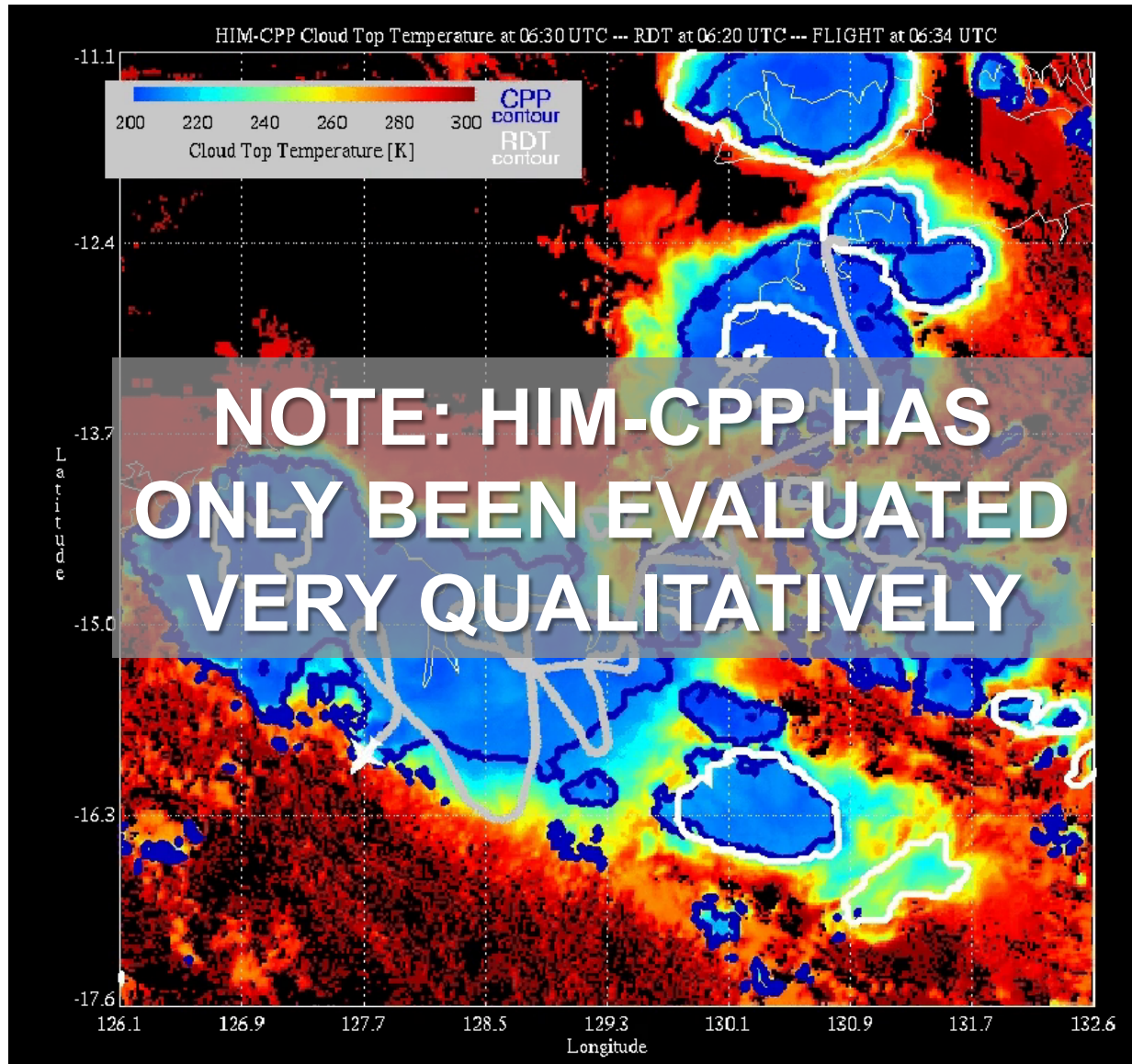


KNMI HIM-CPP web portal



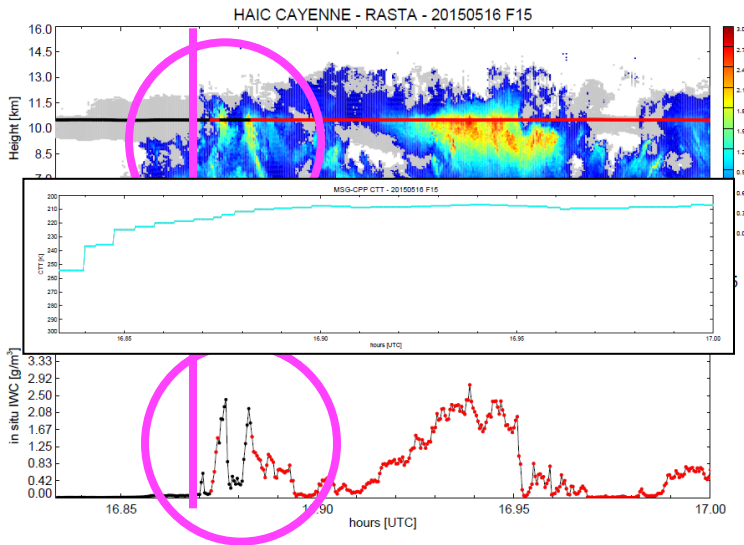
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DARWIN 2016: animation! (14 January 2016)



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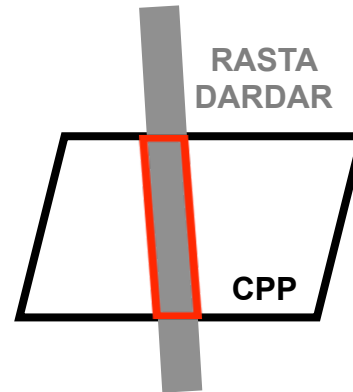
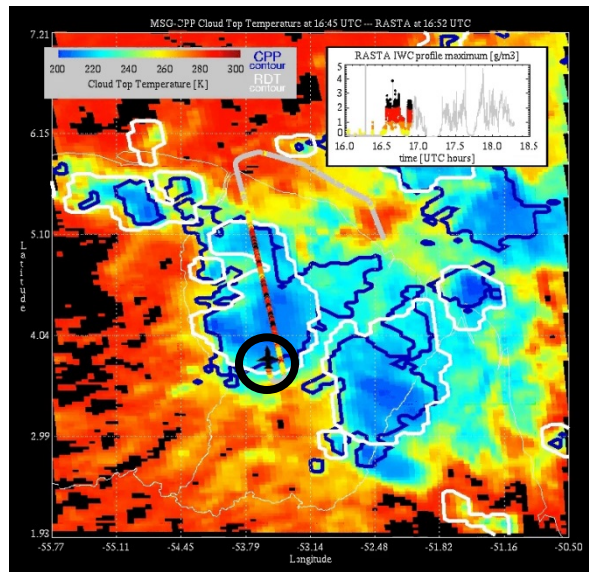
DARDAR/RASTA & CPP High IWC mask: apples – pears ???



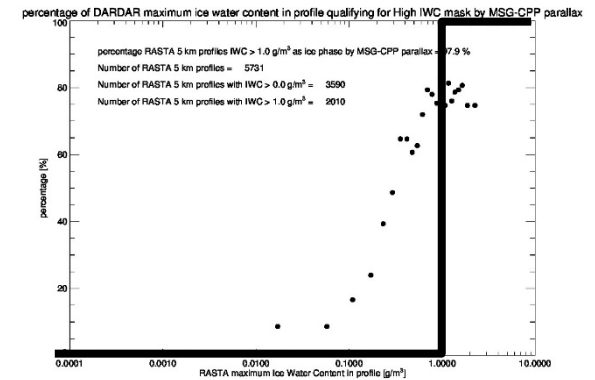
Comparing CPP with DARDAR/RASTA

Differences in spatial resolution

- DARDAR/RASTA ~ few 100 m
- CPP ~ few km (~ 30 seconds)
- Averaging DARDAR/RASTA profiles



MSG-CPP High IWC mask – Cayenne 2015
+ RASTA 5 km averaging
+ parallax correction



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The way forward: where from here?

Remainder HAIC (until end 2016)

- More DARDAR (one full year of data)
- Comparison with on board radar (WXR) [qualitative to quantitative ??]
- IAGOS/MOSAIC

Future HAIC-2 ???

- Further analysis campaign data (so much data has been obtained ...)
- GOES-R/ABI & global product (+ SEVIRI and HIMAWARI)
- Climatology (2004 - now : SEVIRI only)
- Verification data for predictive tools?
- ???

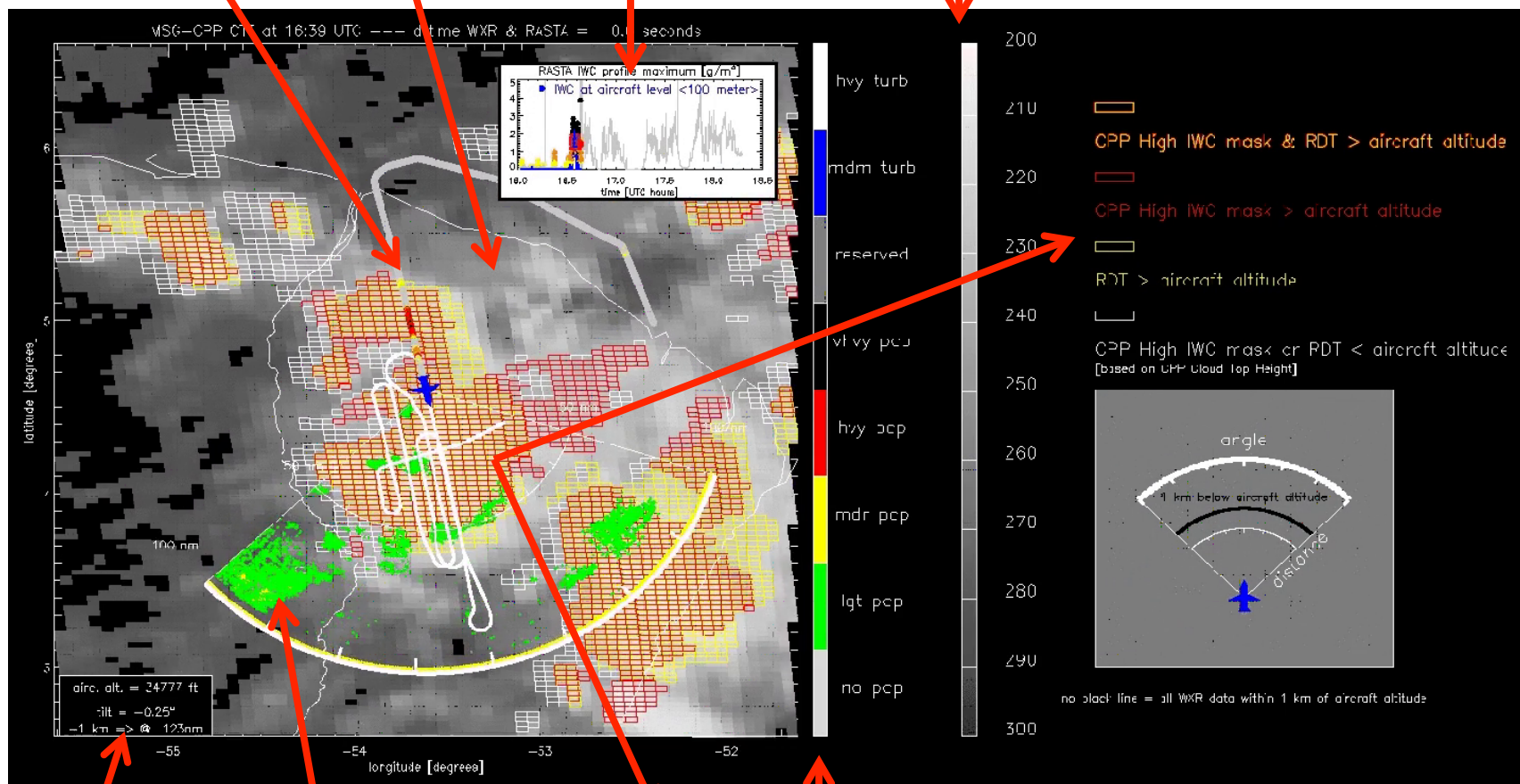
Animation: comparison with on board radar

RASTA at flight level & flight track

CPP Cloud Top Temperature

RASTA max IWC in profile

+ in situ IWC from RASTA



aircraft info

radar signals

CPP/RDT mask

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In conclusion

Summary

- ✓ High IWC mask was developed for geostationary satellite data (15 minutes daytime only)
- ✓ Performance evaluated against LIDAR measurements (both satellites and in situ)
- ✓ Successful in detection scenes with high IWC ($> 1 \text{ g/m}^2$) somewhere in the vertical (cloud)
- ✓ Successfully applied to other geostationary satellite data (HIMAWARI) for 2016 A340 campaign

Issues

- Daytime only
- Trade off between detection and false
- Some solar/viewing angle dependencies found

Towards the future

- Further investigation solar/viewing angle dependencies
- MOZAIC/IAGOS comparison
- Comparison with on board radar (but how to go from qualitative to quantitative?)
- Potential for “global” coverage combining SEVIRI, HIMAWARI, GOES-R (ABI)
- Further evaluation/exploration of HAIC/HIWC campaign data
- Climatology (2004 - now)
- Verification of predictive tools?

...

Inferring High Ice Water Content from the Geostationary Satellite data

That's all

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High Altitude Ice Crystals (HAIC, 314314)

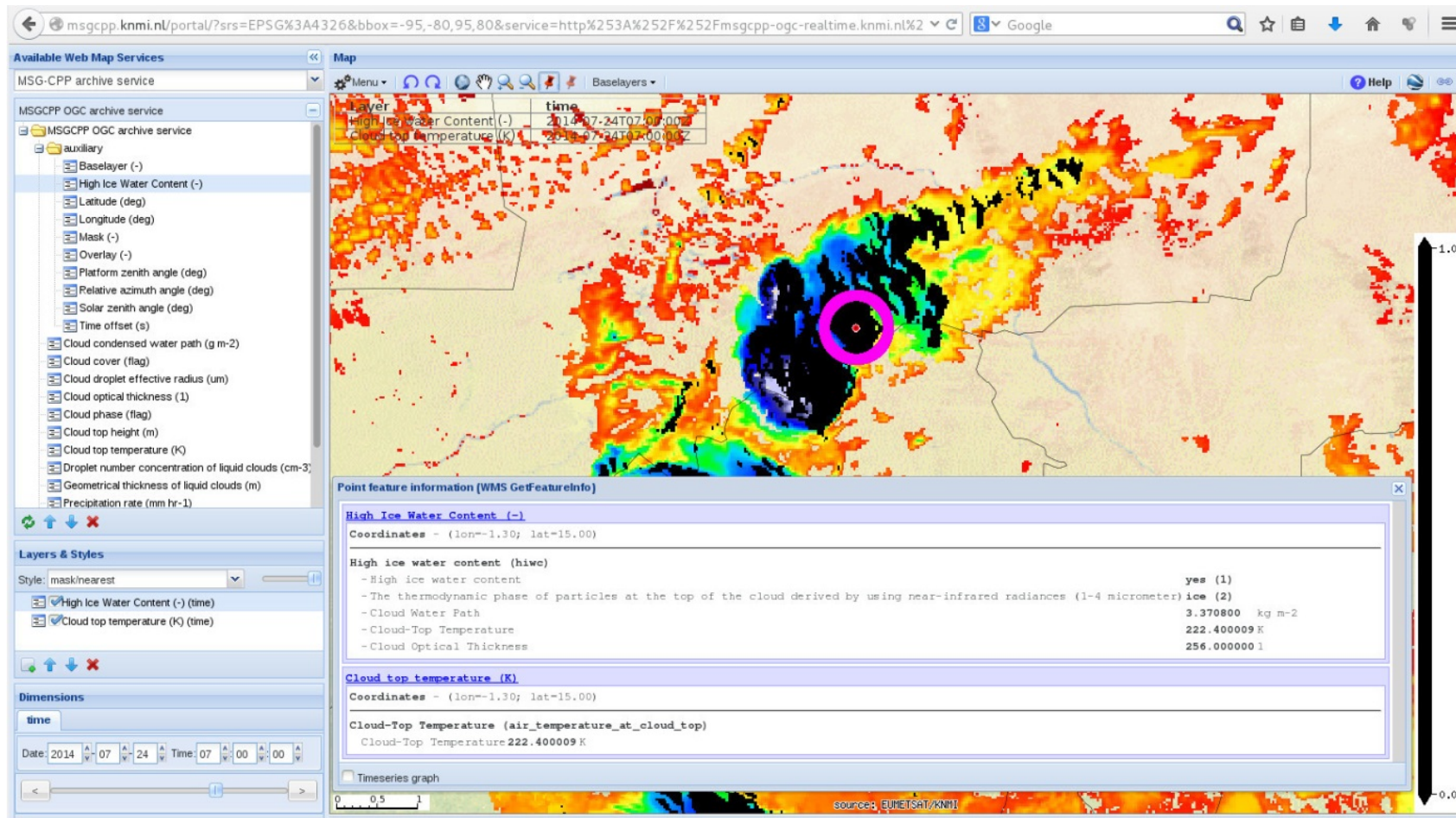
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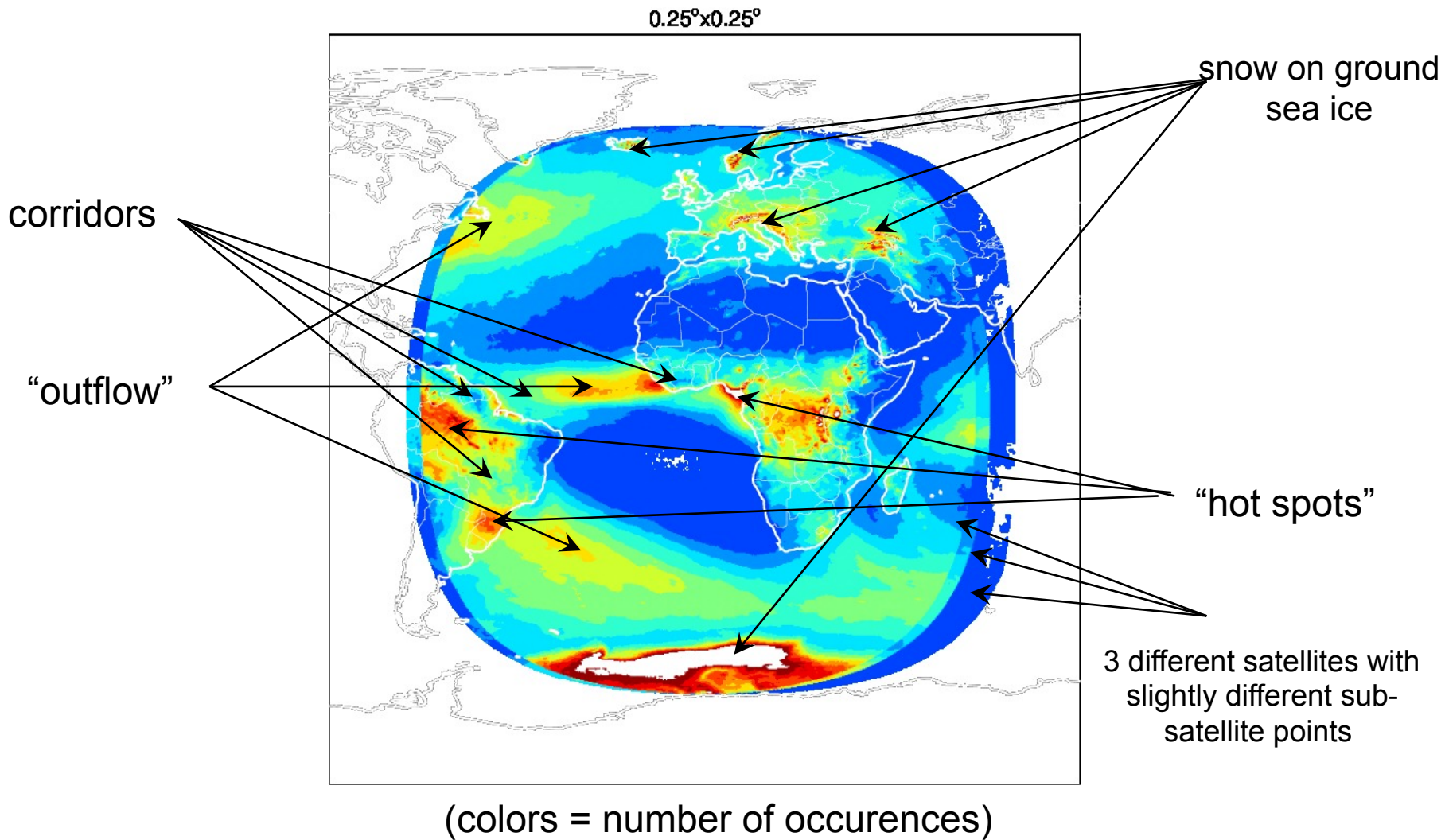
EUROPEAN COMMISSION
European Research Area

An example



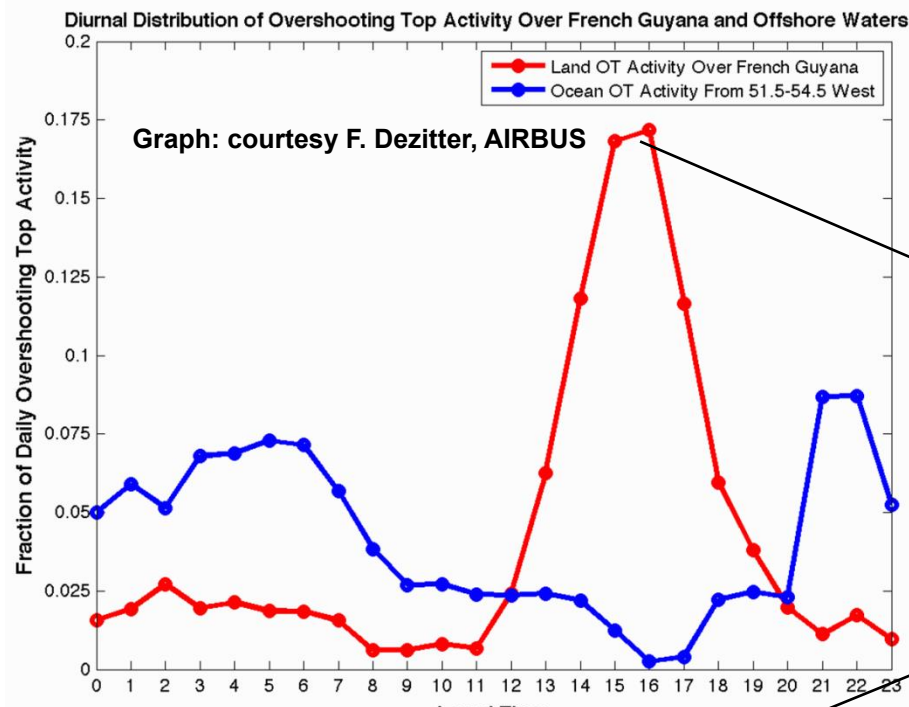
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2004-2014 MSG-CPP HIWC mask climatology

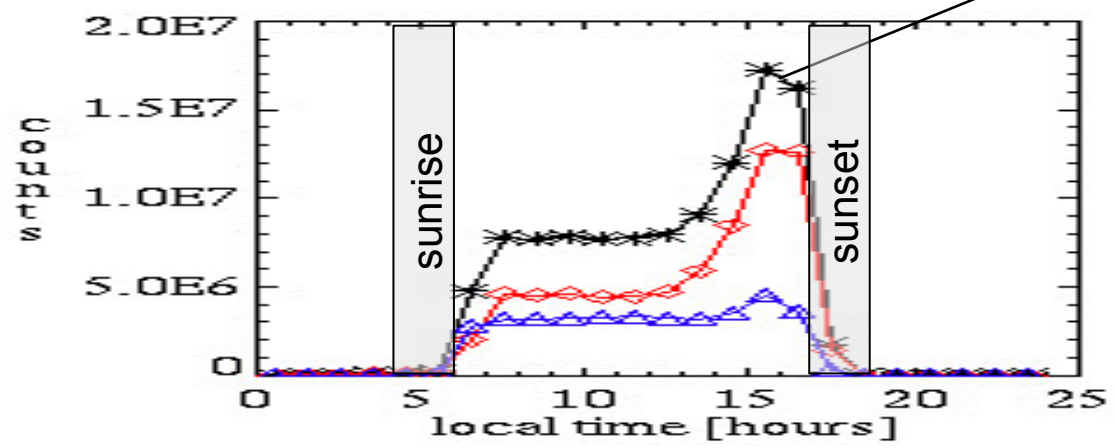


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HAIC Cayenne 2015 field campaign: diurnal cycle



maximum, at 15 - 16 UTC
 (for HIWC mask shifted by 0.5 hours)



Diurnal cycle of High IWC mask for the “larger” Cayenne region (month of May, 2004-2014 average)

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