

Presented by  
E. Defer (CNRS)

Prepared by  
J. De Laat (KNMI), E. Defer (CNRS), J. Delanoë (CNRS),  
F. Dezitter (AI-F), A. Gounou (MET-FR), A. Grandin (AI-F),  
J. F. Meirink (KNMI), J.-M. Moisselin (MET-FR), F. Parol (CNRS),  
S. Turner (ATMOSPHERE), C. Vanbauce (CNRS)  
with the support of HAIC SP1, SP2 and SP4 Teams



# HAIC-HIWC Science Meeting 16-19 May 2016 Toronto, Canada

SP3: SPACE-BORNE OBSERVATION &  
NOWCASTING OF HIGH IWC REGIONS

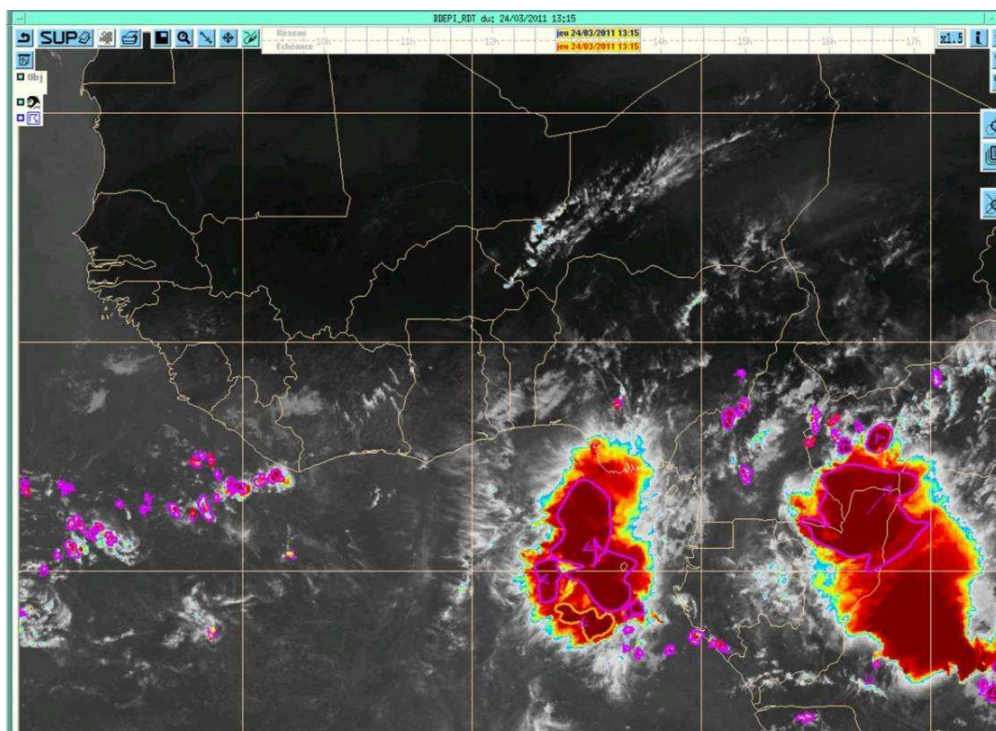
# High Altitude Ice Crystals

## Contents

- Objectives of HAIC SP3 activities
- Reminding the general strategy
- CPP (Cloud Physical Properties) products
- RDT (Rapidly Developing Thunderstorms) tool
- The A-Train mission and the DARDAR product
- TRL5 and TRL6
- Supporting the HAIC 2016 campaign
- Exploring observations of LEO missions
- A first climatology of High IWC
- Way forward

# SP3 Technical Achievements Focus Objectives

To develop **space-borne remote detection and nowcasting techniques of convective systems** to support the first (Darwin, 2014) second (Cayenne, 2015) and third (Australia-La Réunion, 2016) HAIC flight test campaigns, and to ultimately provide near real-time weather data through ATM as being studied as part of SESAR



*Deep tropical convective supercells processed by RDT*

# SP3 Technical Achievements Focus

## SP3 Activities

### **Geostationary Space-borne Retrievals of High IWC [KNMI]**

- Detection of high IWC cloud regions in daytime mainly from the VIS/IR SEVIRI imager on MSG (Europe, Africa, Atlantic Ocean)
- Validate the MSG-SEVIRI-based retrievals of ice cloud properties

### **Polar Orbiting Space-borne Retrievals of High IWC [CNRS]**

- Detection of any specific signature of High IWC in concurrent visible, infrared and microwave passive and active observations of the space-based A-Train mission
- Develop a reference global-scale climatology of frequency of high IWC occurrence

### **Nowcasting of Tropical Convection [Météo-France]**

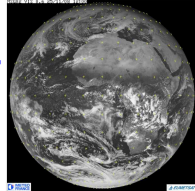
- Develop and validate a detection and nowcasting application for deep convection over the Tropical Atlantic for real-time guidance of the aircraft during the HAIC flight campaign and further support to ATM



# SP3 Technical Achievements Focus

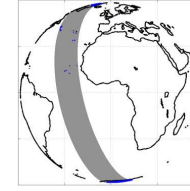
## Reminding the General Observational-based Strategy

KNMI CPP  
MET-FR RDT

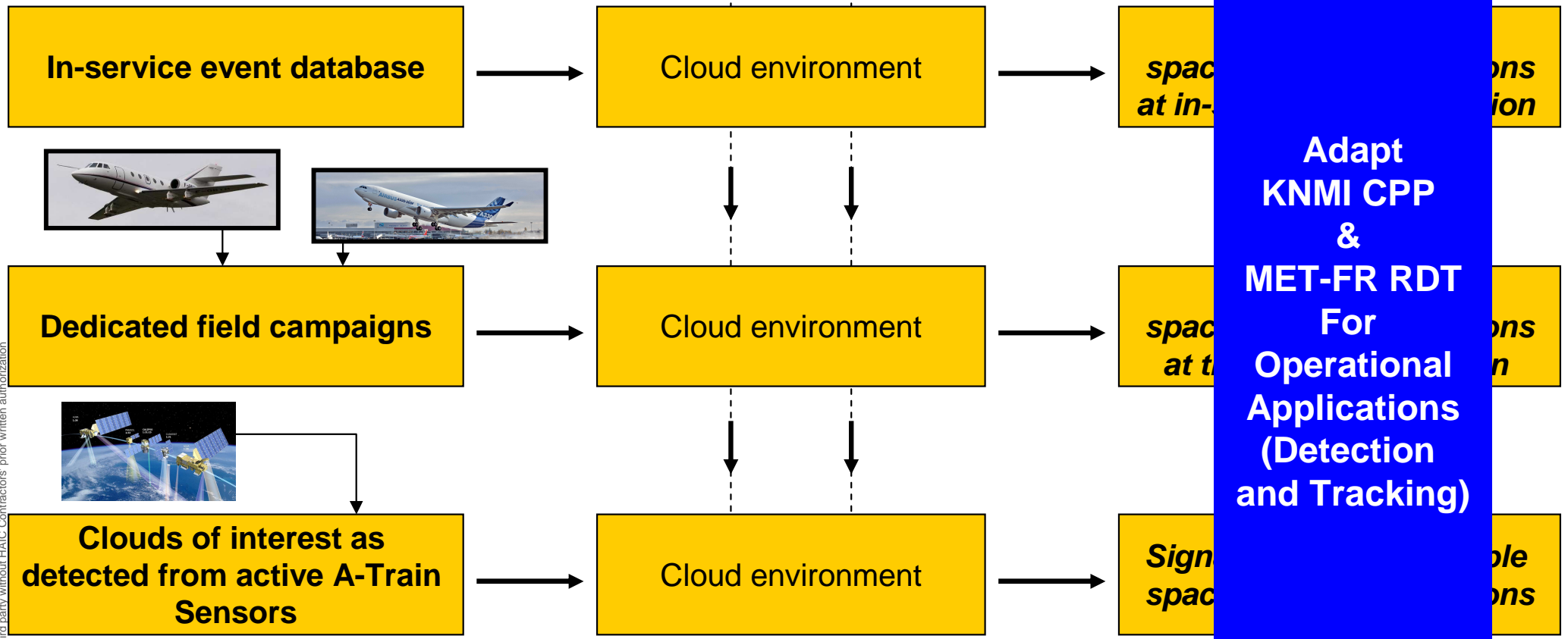


GEO

LEO



A-Train  
(TRMM)



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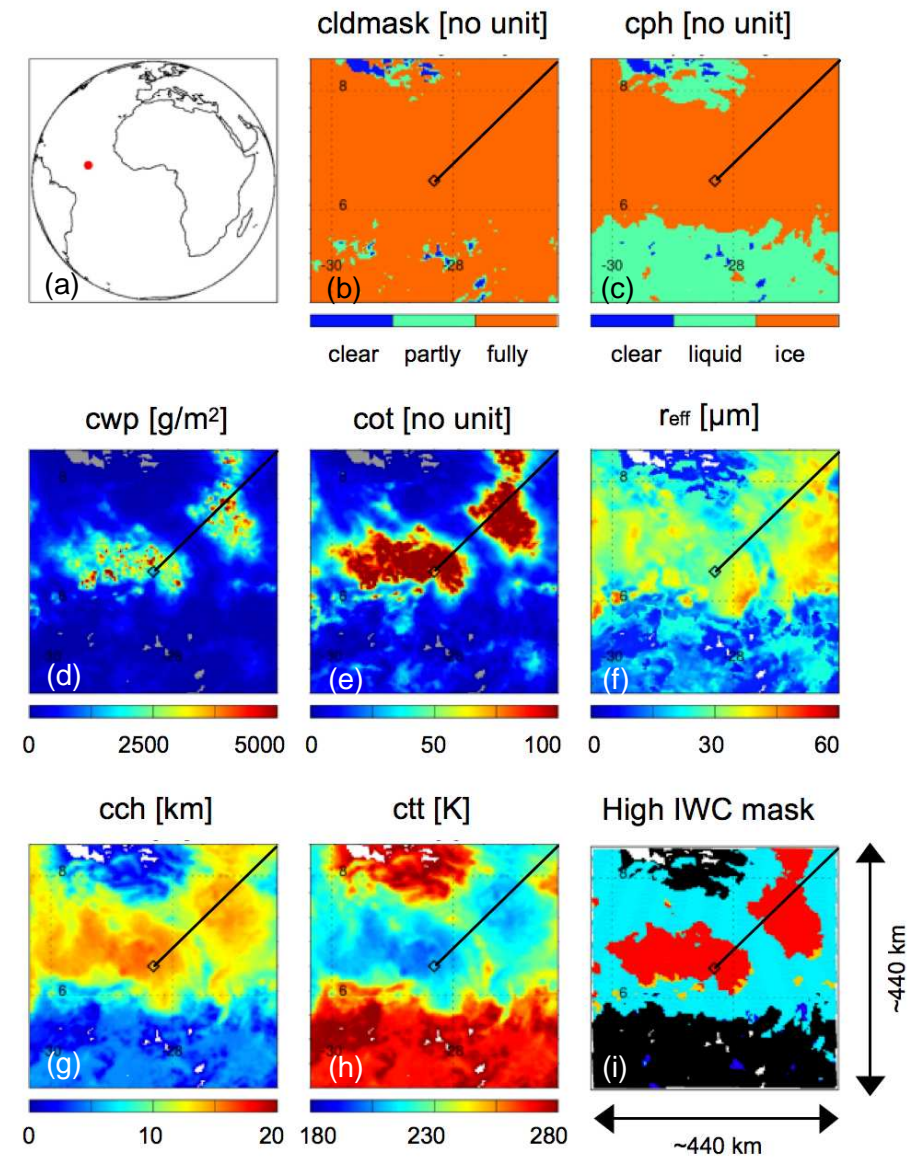


# SP3 Technical Achievements Focus CPP (Cloud Physical Properties) Products

See Jos' presentation

## Retrieval technique providing cloud properties

- EUMETSAT SAF "Climate"
- Applied on Meteosat Second Generation VIS and NIR channels
- Daytime products
- Retrieve the particle effective radius at cloud top, cloud mask, cloud top phase, cloud water path, cloud top height, cloud top temperature...
- Validated using ground-based and satellite observations
- Development, validation and operational implementation of VIS/NIR High IWC detection



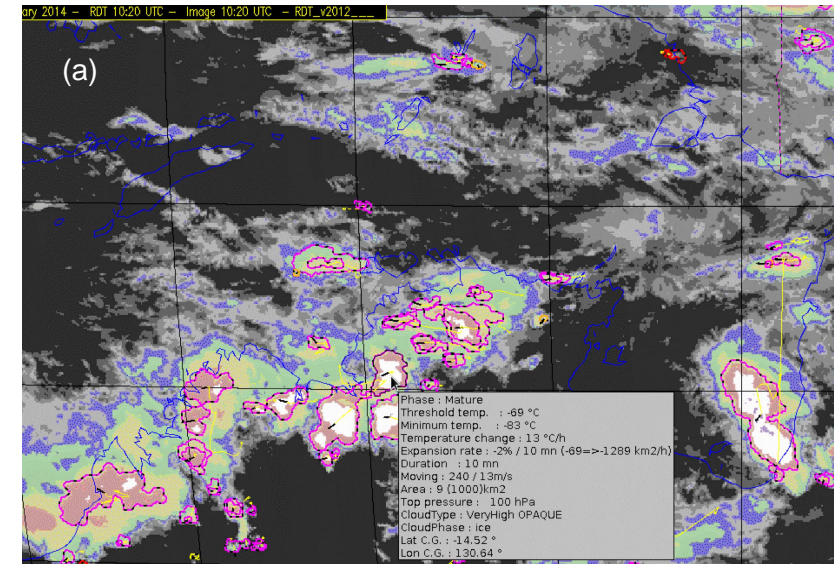
CPP products at the time of  
an in-service event

# SP3 Technical Achievements Focus

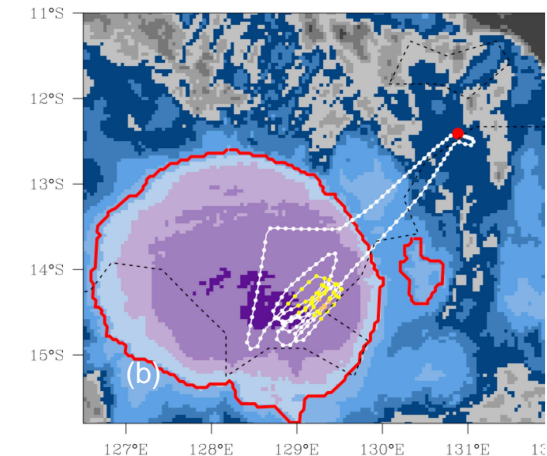
## RDT (Rapidly Developing Thunderstorms) Tool

### Detection and tracking techniques of convective clouds

- EUMETSAT SAF “Nowcasting”
- Applied on Meteosat Second Generation channels
- Can be used with other GEO satellites
- Day & night products
- Identify convective and retrieve cloud top altitude, contour, level of maturity...
- Track identified cells
- Validated using ground-based lightning observations
- Development, validation and operational implementation of detection and tracking of High IWC cloud regions



*Real time RDT product (top) and post-campaign HAIC/HIWC analysis (bottom)*



# SP3 Technical Achievements Focus

## The A-Train Mission

### Detection and characterization of the convective clouds

- Active techniques
  - Cloud radar, lidar
  - DARDAR products
- Passive techniques
  - Visible, IR and MW imagery
  - POLDER & MODIS products
  - AMSRE MW brightness temperatures
- Investigate specific VIS/NIR/IR/MW signatures of High IWC cloud region based on DARDAR IWC retrieval
- Support for the validation, training and improvement of SP3 algorithms

Instruments <sup>(1)</sup>	Available products
POLDER/Parasol MODIS/Aqua [Vis/NIR]	Cloudiness, cloud pressure, optical depth, albedo, particle size, particle thermodynamic phase,...
MODIS/Aqua [IR]	Cloudiness, cloud top temperature, cloud top altitude, emissivity, particle size,...
AMSRE/Aqua [MW]	Brightness Temperatures
Caliop/Calipso [lidar]	Optical depth, cloud depth, cloud particle phase,...
CPR/Cloudsat [cloud radar]	Cloud mask, classification, IWC, LWC, PSD,...

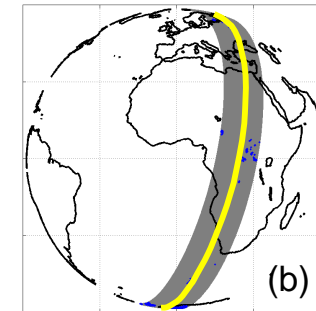
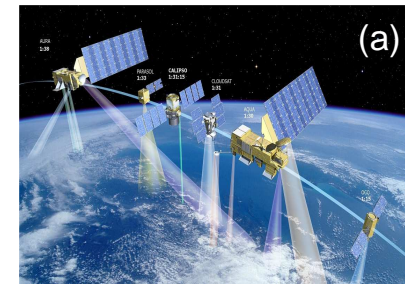
(1) Other missions are also considered like TRMM, GPM, Modis/Terra



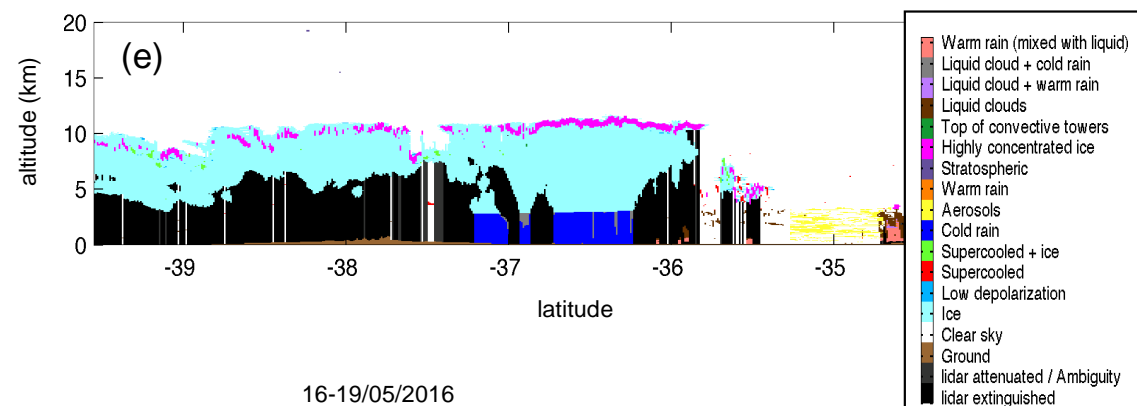
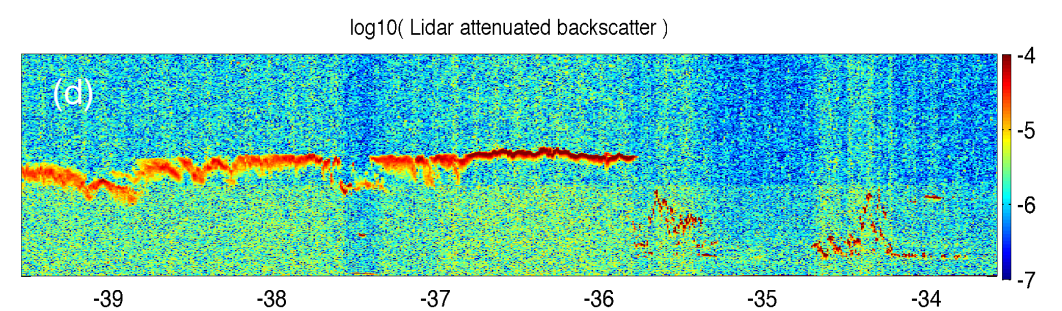
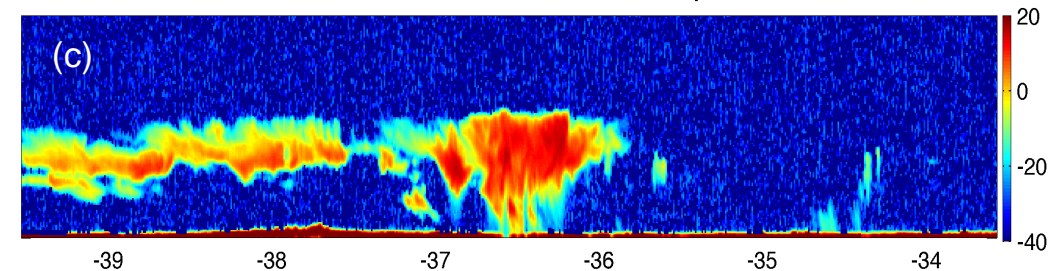
# SP3 Technical Achievements Focus

## The DARDAR Product

- Combination of coincident radar (95 GHz) and lidar (532 & 1064 nm) space-borne A-Train observations sensitive to different properties of the clouds (phase, particle size distribution)
- Capability to retrieve the vertical distribution of IWC and  $r_e$  through a variational approach
- Capability to classify the cloud type at each altitude bin
- Always concurrent visible, infrared and microwave observations available of the A-Train mission
- Global coverage but small swath
- *RASTA mimics the A-Train radar*



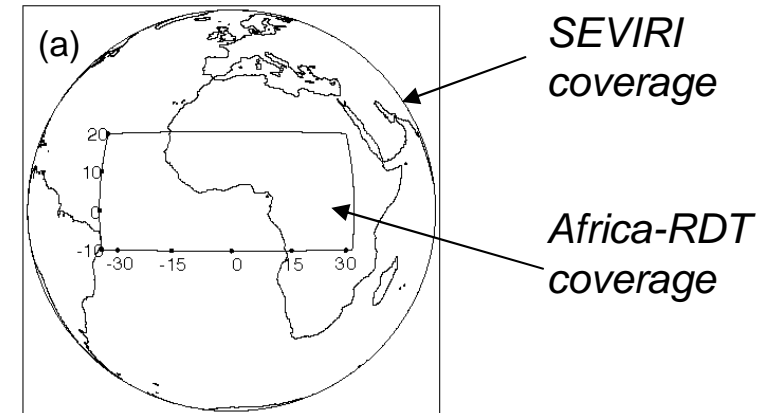
CLOUDSAT 2B GEOPROF Radar Reflectivity



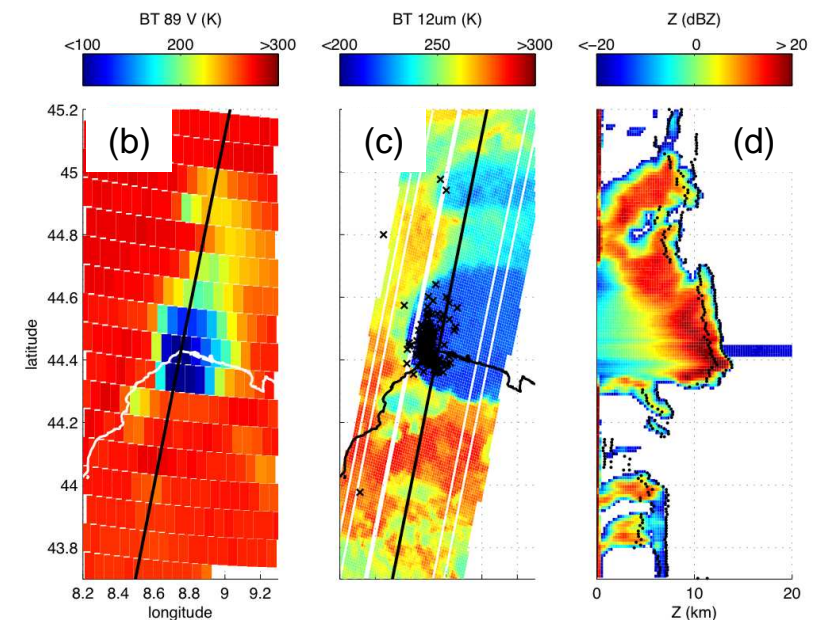
# SP3 Technical Achievements Focus

## A Strategy for Evaluation and Signature Investigation

- Selection of the DARDAR data for year 2008, day & night overpasses located in SEVIRI and Africa-RDT coverage areas
- Evaluation of the operational products:
  - ▶ Refinement and validation of KNMI High IWC mask
  - ▶ Assess the performances of RDT operated over Africa
- Exploring High IWC signature in concurrent passive visible, infrared and microwaves
  - ▶ Expand the DARDAR swath
  - ▶ Apply to other LEO missions
- Development of dedicated software to extract, plot and analyze the data
- Methodology discussed during the SP3 Live Data Analysis meeting (M32)



Example of A-train observations

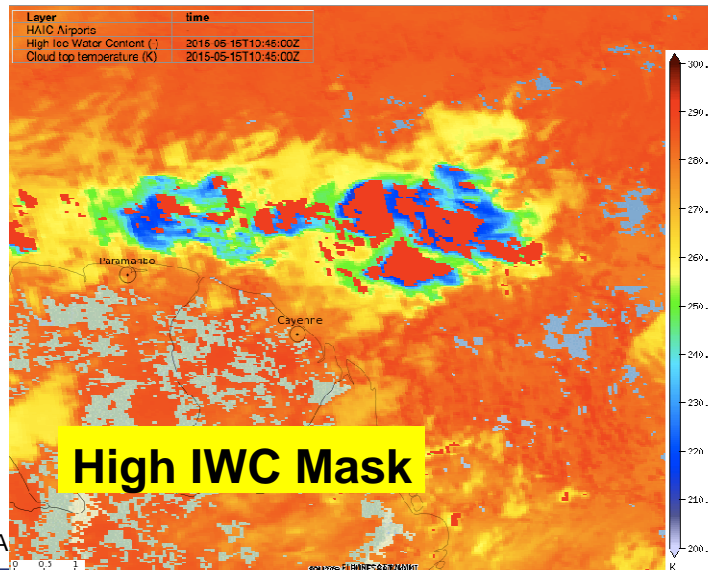




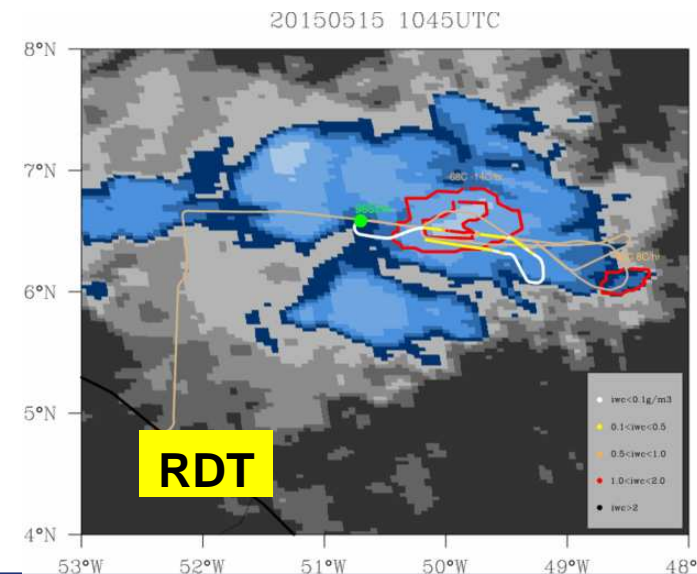
# SP3 Technical Achievements Focus

## Conclusive TRL5 Review

- Operational aspects of WP32 and WP34 products demonstrated through HAIC-HIWC 2015 campaign
- Validation of the satellite-based detection schemes relatively to HAIC-HIWC 2014 and 2015 campaigns and A-Train observations
  - ▶ Comparison with ROBUST records, RASTA/DARDAR IWC profiles
  - ▶ Performance assessment as a function of IWC range; contingency tables
  - ▶ A wish list, including flight plans, provided before HAIC 2016 campaign for new validation exercises



HAIC – High A



# SP3 Technical Achievements Focus In Route for TRL6

- TRL6 review planned for December 2016
- Should be mainly assessed for MSG coverage area
  - ▶ Use of HAIC-HIWC 2015 and HAIC 2016 MSG records
  - ▶ However HAIC-HIWC 2015 MTSAT and HAIC 2016 HIMAWARI records will be explored
- Additional in situ dataset considered (e.g. ACCRIDICON campaign, IAGOS flights) and re-verification relatively to AIRBUS in-service events
- Need to explore new methods to quantify the space-based algorithms at the cell and regional scales
- Consider the temporal and spatial evolution of the clouds (to be discussed during the Satellite and Nowcasting Session)

# SP3 Technical Achievements Focus

## SP3 activities in support to the HAIC-2016 campaign

- SP3 products developed to support the third HAIC campaign (DoW)
- Verification and validation of SP3 products through HAIC-2016 campaign to demonstrate TRL6 maturity
  - ▶ Required the HAIC-2016 campaign to be located in MSG-SEVIRI domain to be consistent with DoW
  - ▶ Based on High IWC climatology, SP3 originally suggested Madagascar
- Three locations : **Indonesia**, **Australia**, **La Réunion**
  - ▶ WP32 : **development of a new CPP chain operated on Japanese HIMAWARI-8 (different from the European SEVIRI sensor); use of HAIC-2015 configuration (SEVIRI)**
  - ▶ WP33 : **no impact (expected higher revisiting overpasses for Megha-Tropiques)**
  - ▶ WP34 : **development of a new RDT chain operated on Japanese HIMAWARI-8 (new spatial resolution); development of two new RDT chains operated on MSG and M7 observations**
- GEO data transferred to SP3 teams through different ways for an optimal operational support during HAIC-2016

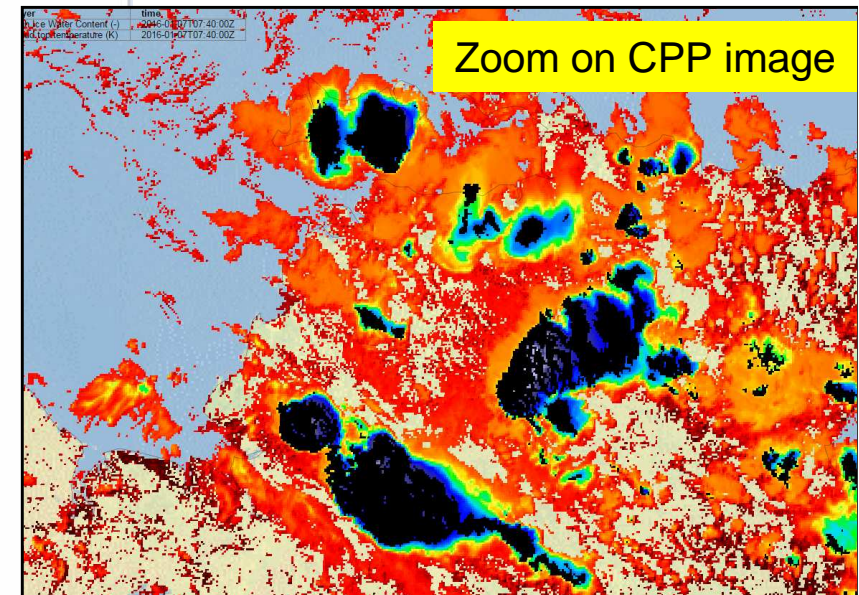
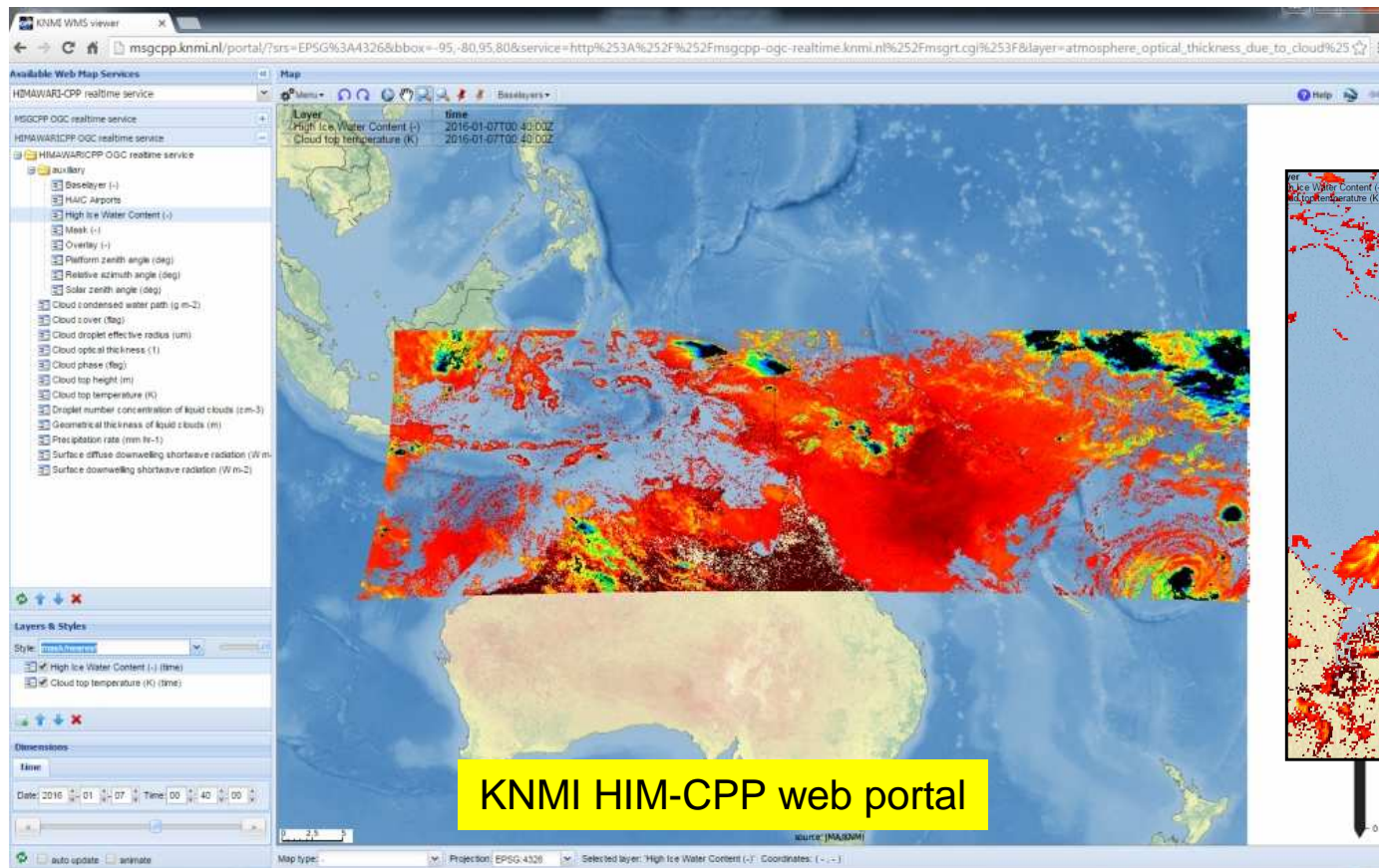


# SP3 Technical Achievements Focus

## Preparation to the HAIC-2016 campaign (1/3)

See Jos' presentation

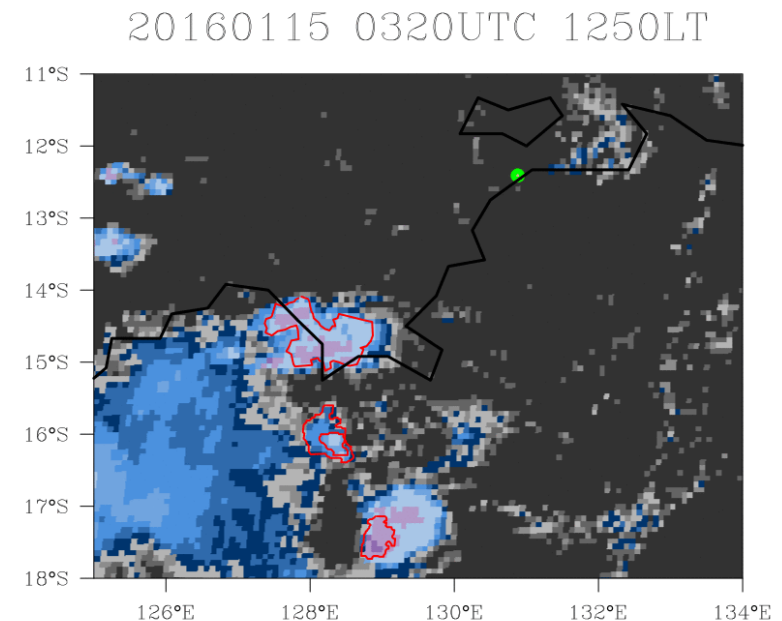
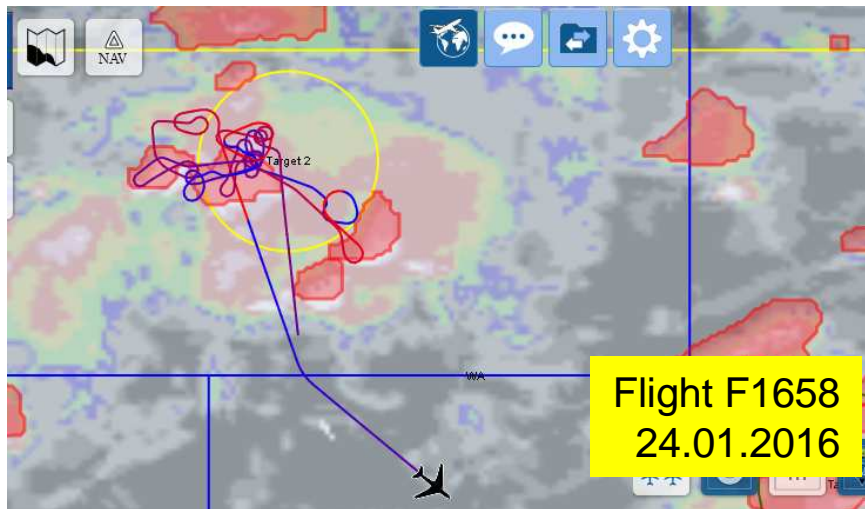
- Development of a dedicated HIM-CPP chain by KNMI
  - ▶ Adaptation and tuning of the CPP algorithms to the HIMAWARI channels
  - ▶ Implementation for real time display via KNMI web portal
  - ▶ Limited area (not full disc) to get fast access to data on ftp-server



# SP3 Technical Achievements Focus

## Preparation to the HAIC-2016 campaign (2/3)

- Development of three dedicated RDT chains by MET-FR
  - ▶ Adaptation and tuning of the RDT algorithm to the HIMAWARI-8 observations (spatial resolution) over Indonesia and Australia
  - ▶ Adaptation and tuning of the RDT algorithm to the MSG and M7 records over La Réunion
  - ▶ Transfer of the IR satellite images and RDT products to the A340 aircraft through ATMO-PLANET (activity extended over Europe in February 2016)
  - ▶ Redundancy applied for reliable data transfer from HIMAWARI-8 data server





# SP3 Technical Achievements Focus

## Preparation to the HAIC-2016 campaign (3/3)

- 5-day forecasts of LEO mission orbits via IPSL-IXION software (images for HAIC Operation Center, CSV files for ATMO-PLANET)
- Some coincident overpasses (Terra/MODIS, Megha-Tropiques) **but no coordinated flights possible with A-Train**

Orbits LEO as of 2016/01/15... HAIC - Indonesia 2016 Campai...

file:///C:/Users/defe/Downloads/Orbits\_asof\_20160115/haic\_overpasses\_png.htm

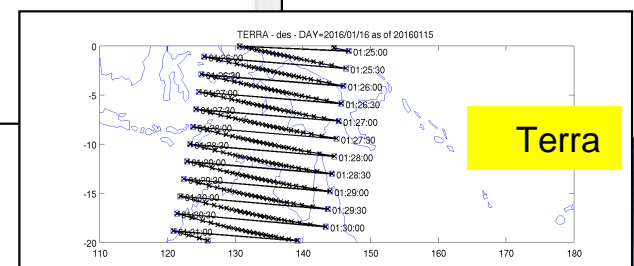
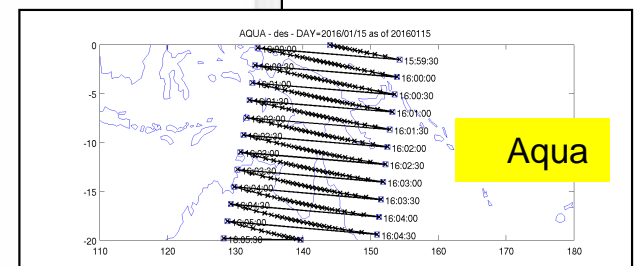
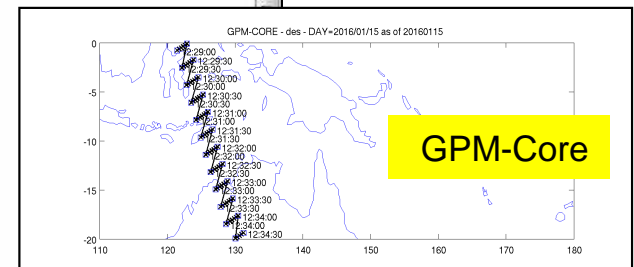
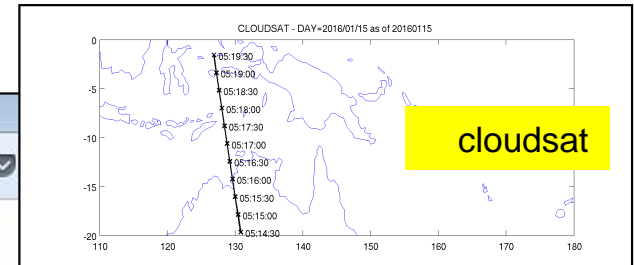
LEO Satellite Overpasses Based on IPSL-IXION (<http://climserv.ipsl.polytechnique.fr/ixion/>)  
Last update : 15-Jan-2016

[CSV files](#)

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CLOUDSAT -- 20160115 - 20160116 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
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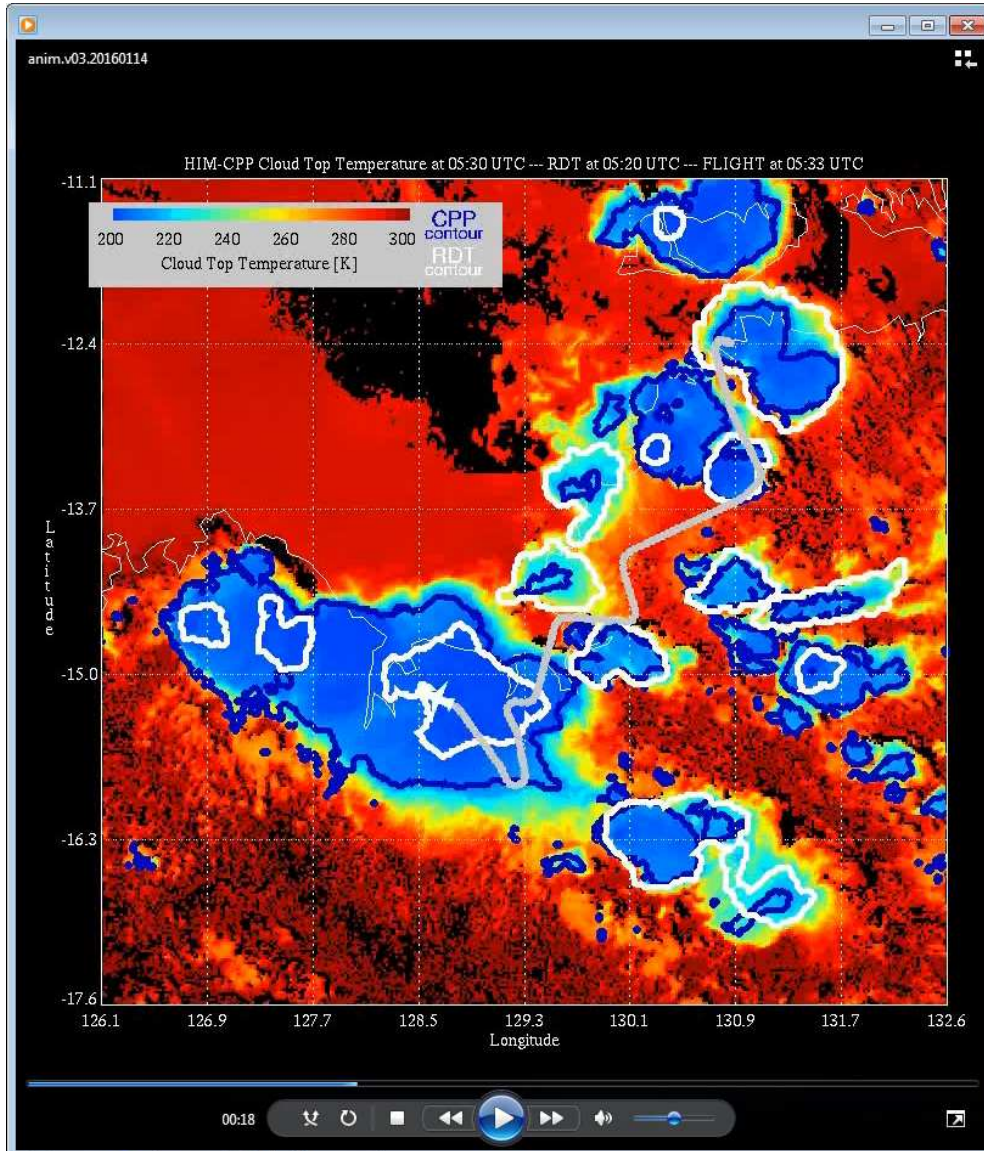




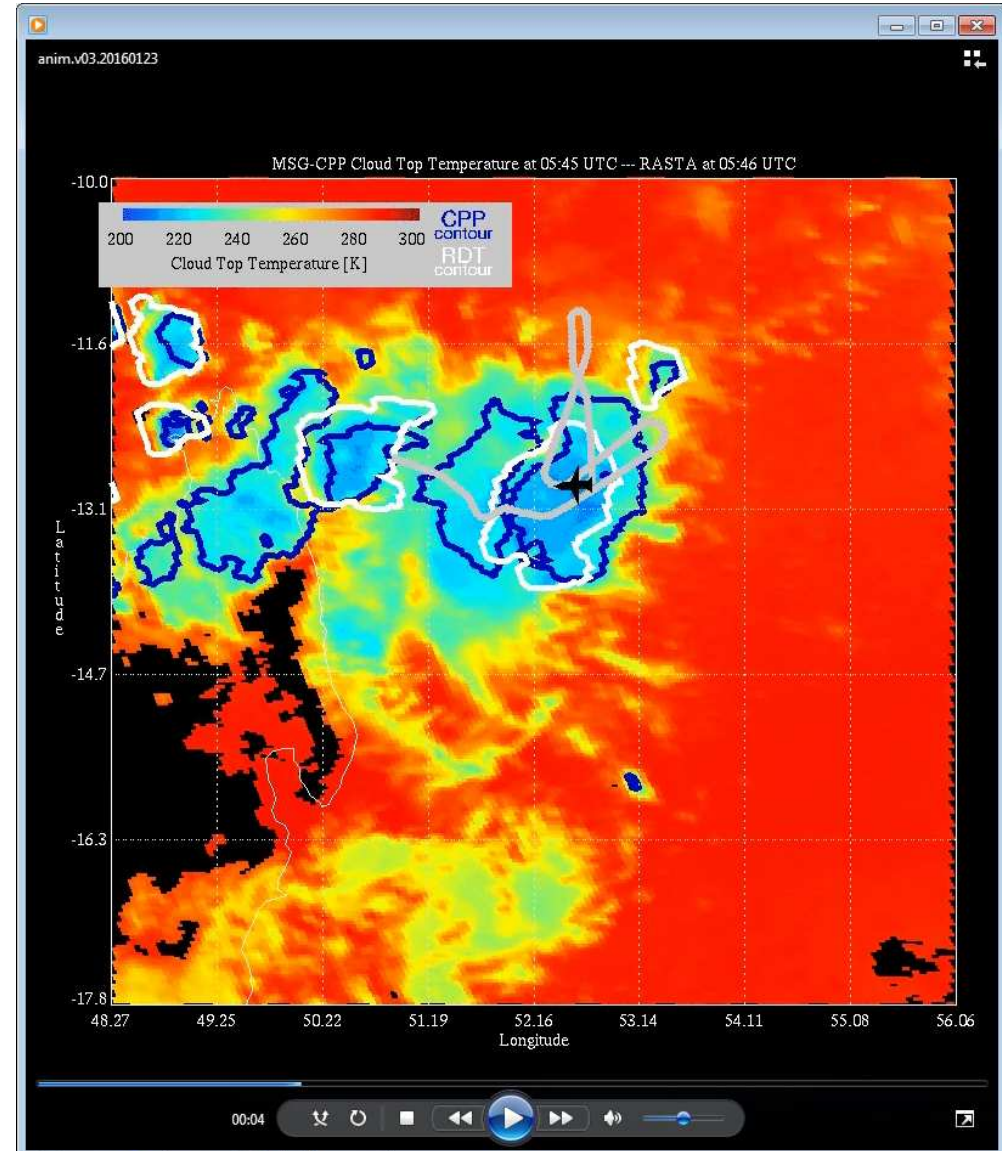
# SP3 Technical Achievements Focus

## HAIC-2016 - 14 Jan. 2016 flight & 23 Jan. 2016 flight

### Australia

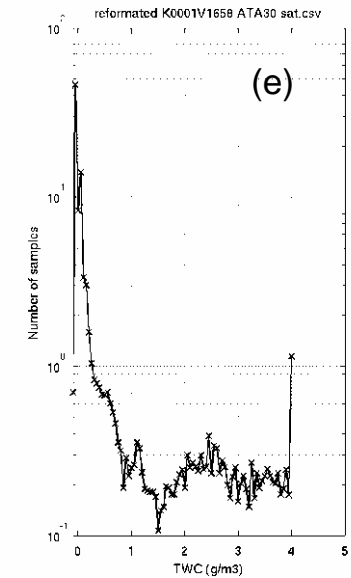
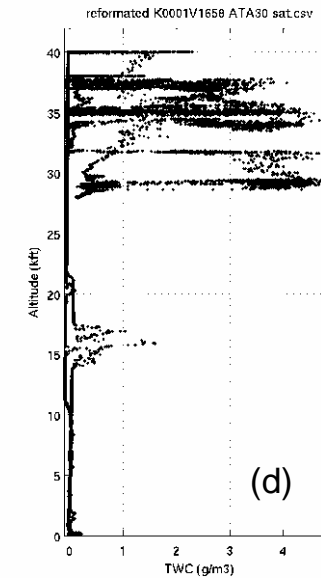
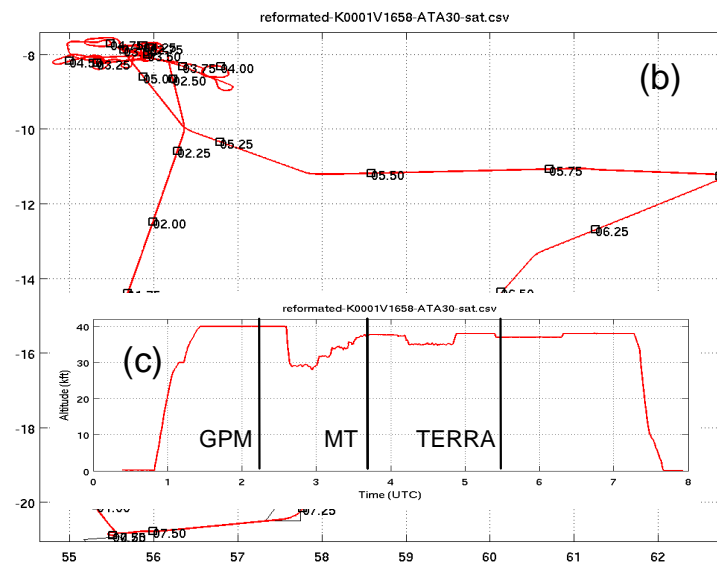
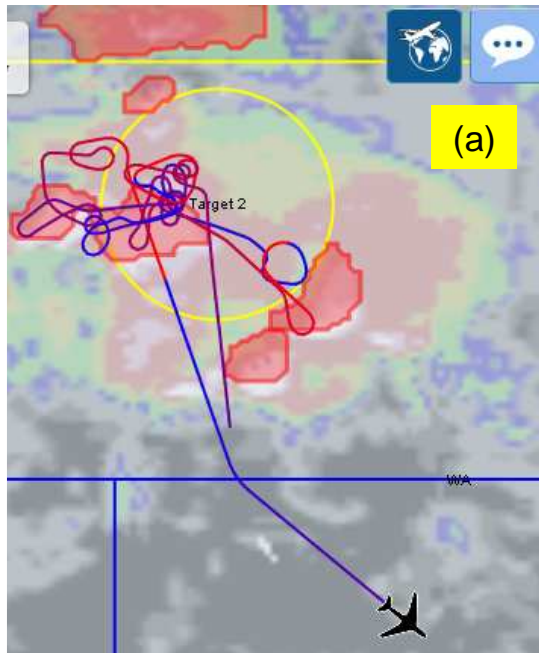


### La Réunion

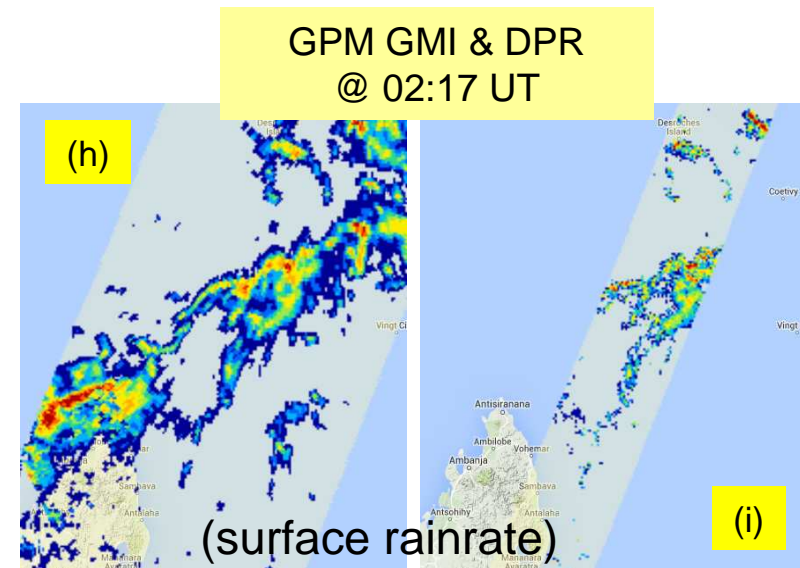
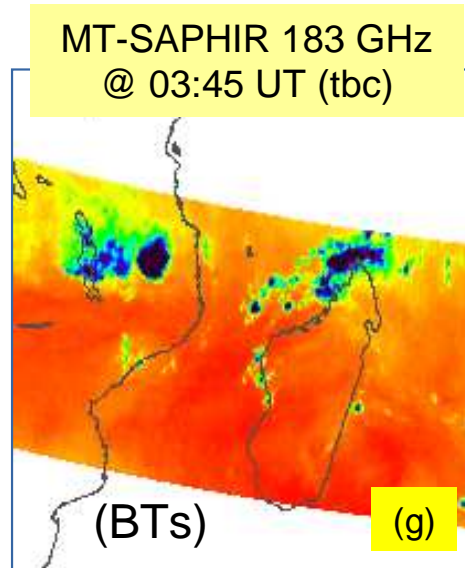
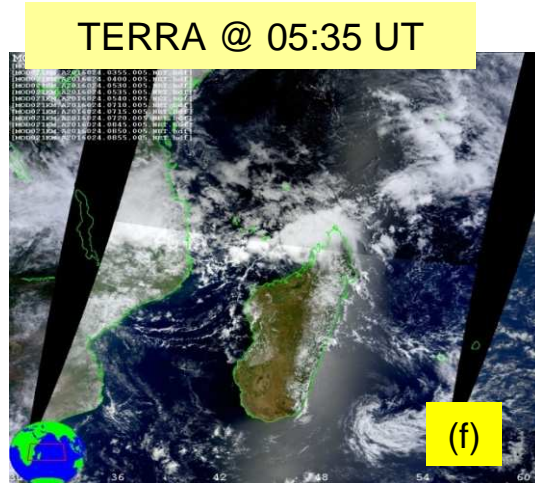


# SP3 Technical Achievements Focus

## HAIC-2016 - 24 Jan. 2016 flight – LEO missions



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# SP3 Technical Achievements Focus

## Table of MODIS acquisitions for HAIC 2016 campaign

#	Date	T-Off – Landing Time (UTC)	MODIS Terra (DAY) (UTC)	MODIS Aqua (DAY) (UTC)	MODIS Terra (NIGHT) (UTC)	MODIS Aqua (NIGHT) (UTC)
<i>Australia</i>						
F1652	13/01/2016	06:45 – 09:00	00:55	05:25	13:10	16:15
F1653	14/01/2016	04:45 – 08:50	01:40	04:25	13:55	16:55
F1654	15/01/2016	03:55 – 09:00	02:25	05:15	14:40	16:00
<i>La Réunion</i>						
F1657	23/01/2016	02:20 – 09:30	06:30	11:00 (*)	18:00	21:05
F1658	24/01/2016	00:50 – 07:40	05:35 & 07:15 (**)	10:00	18:50	21:50
F1659	27/01/2016	00:50 – 06:55	06:10	10:35	19:20	20:40

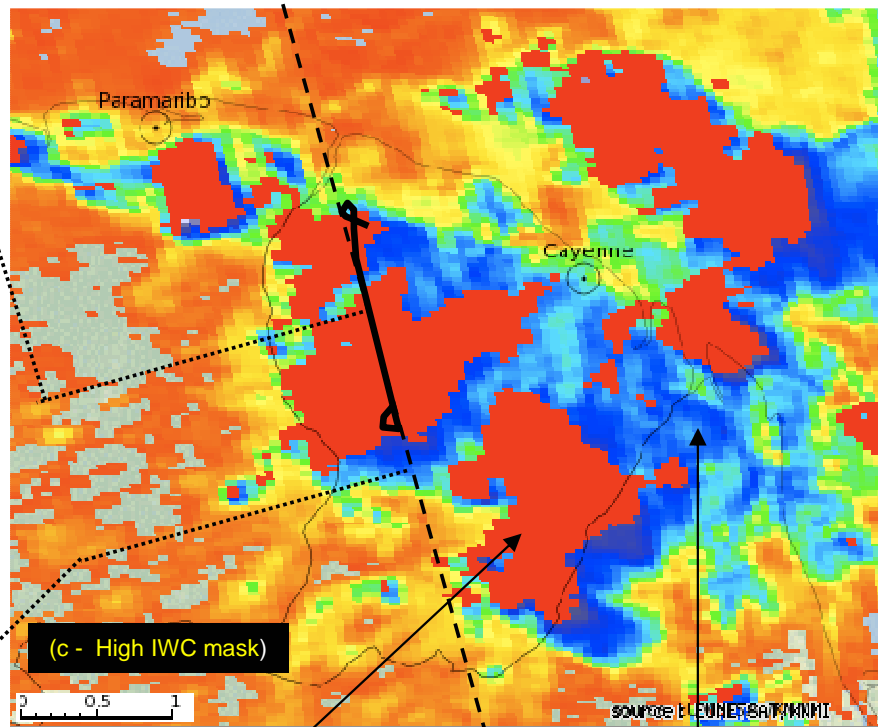
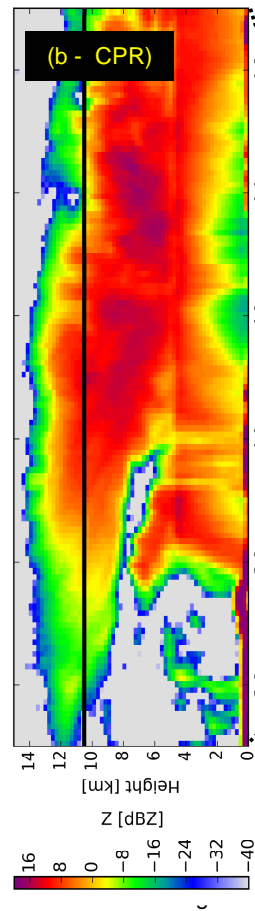
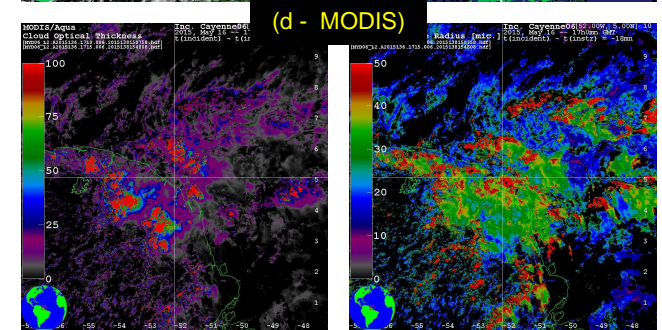
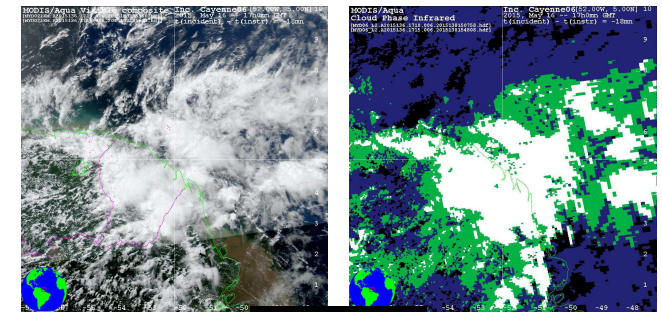
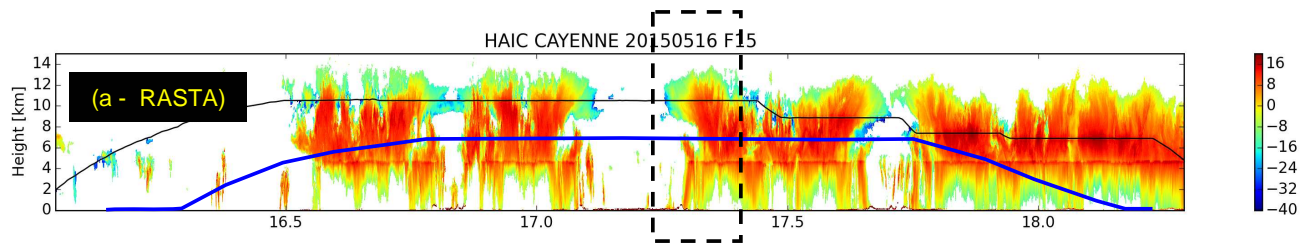
(\*) only for the West part of the flight (corresponding to 04:00 – 05:00 flight time); the East part of the flight is between two MODIS Aqua swaths

(\*\*) 05:35 is for the East part of the flight (corresponding to 06:00 – 07:00 flight time)  
07:15 is for the West part of the flight (corresponding to 01:00 – 05:00 flight time)

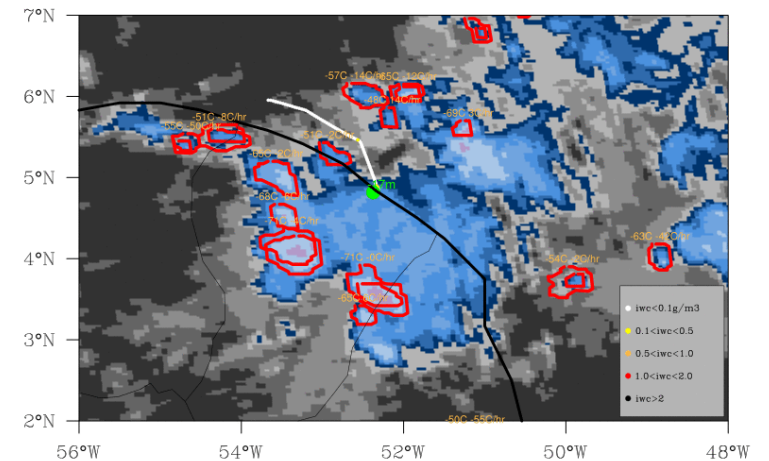
# SP3 Technical Achievements Focus

## HAIC-2015 – Analysis of the cases (1/3)

- Coordinated flights with A-Train overpass on 16 May 2015 @ 17:15 UT



(e - High IWC mask) 1600UTC



High IWC mask

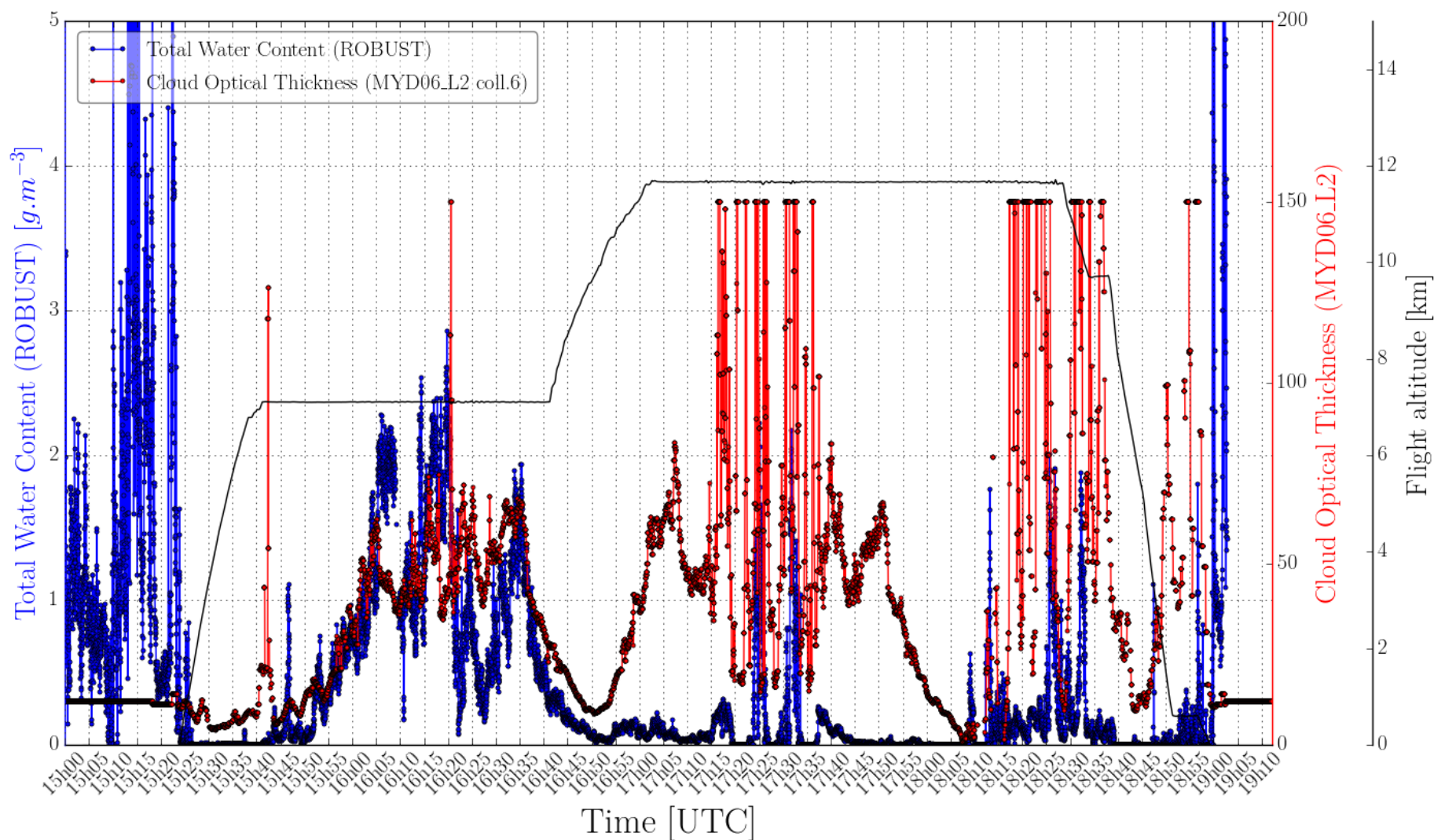
Cloud top temperatures

de Ice Crystals (314314)

# SP3 Technical Achievements Focus

## HAIC-2015 – Analysis of the cases (2/3)

CAYENNE campaign - ROBUST F19 2015/05/23 - AQUA



First example : MODIS – ROBUST comparison

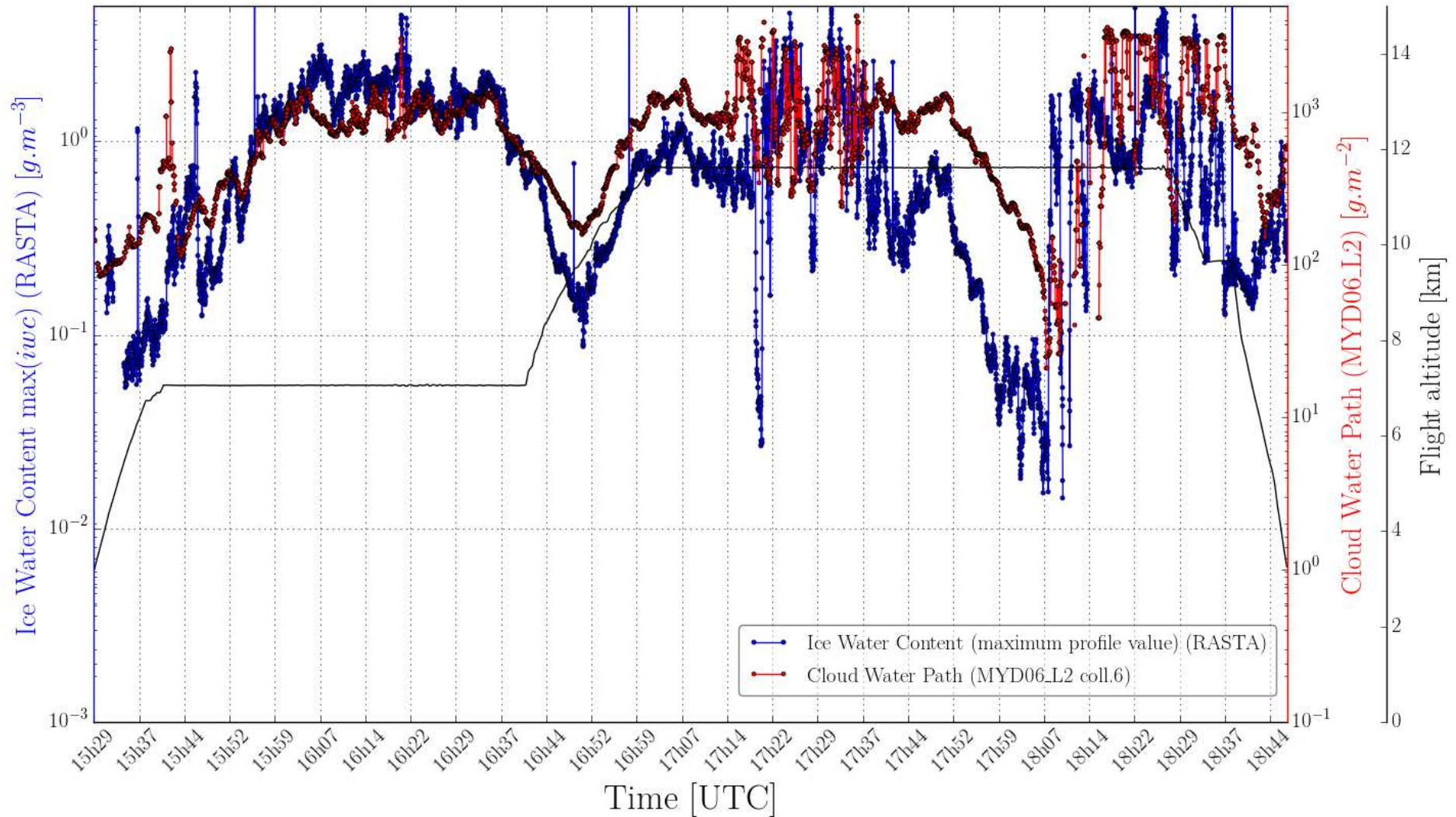
← Overpass time



# SP3 Technical Achievements Focus

## HAIC-2015 – Analysis of the cases (3/3)

CAYENNE campaign - RASTA F19 2015/05/23 - AQUA



Second example : MODIS – RASTA comparison

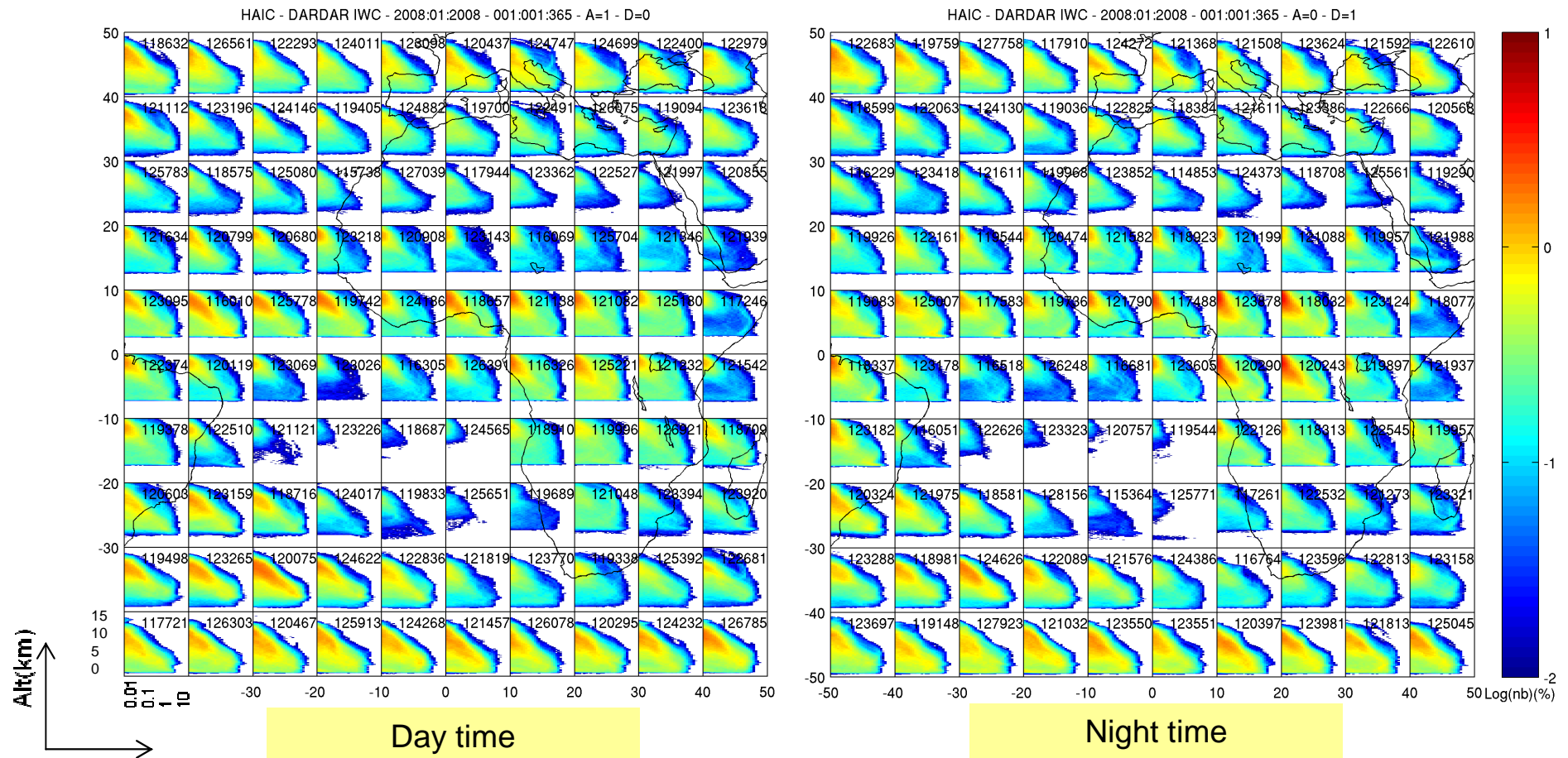
← Overpass time



# SP3 Technical Achievements Focus

## High IWC Climatology from DARDAR (1/2)

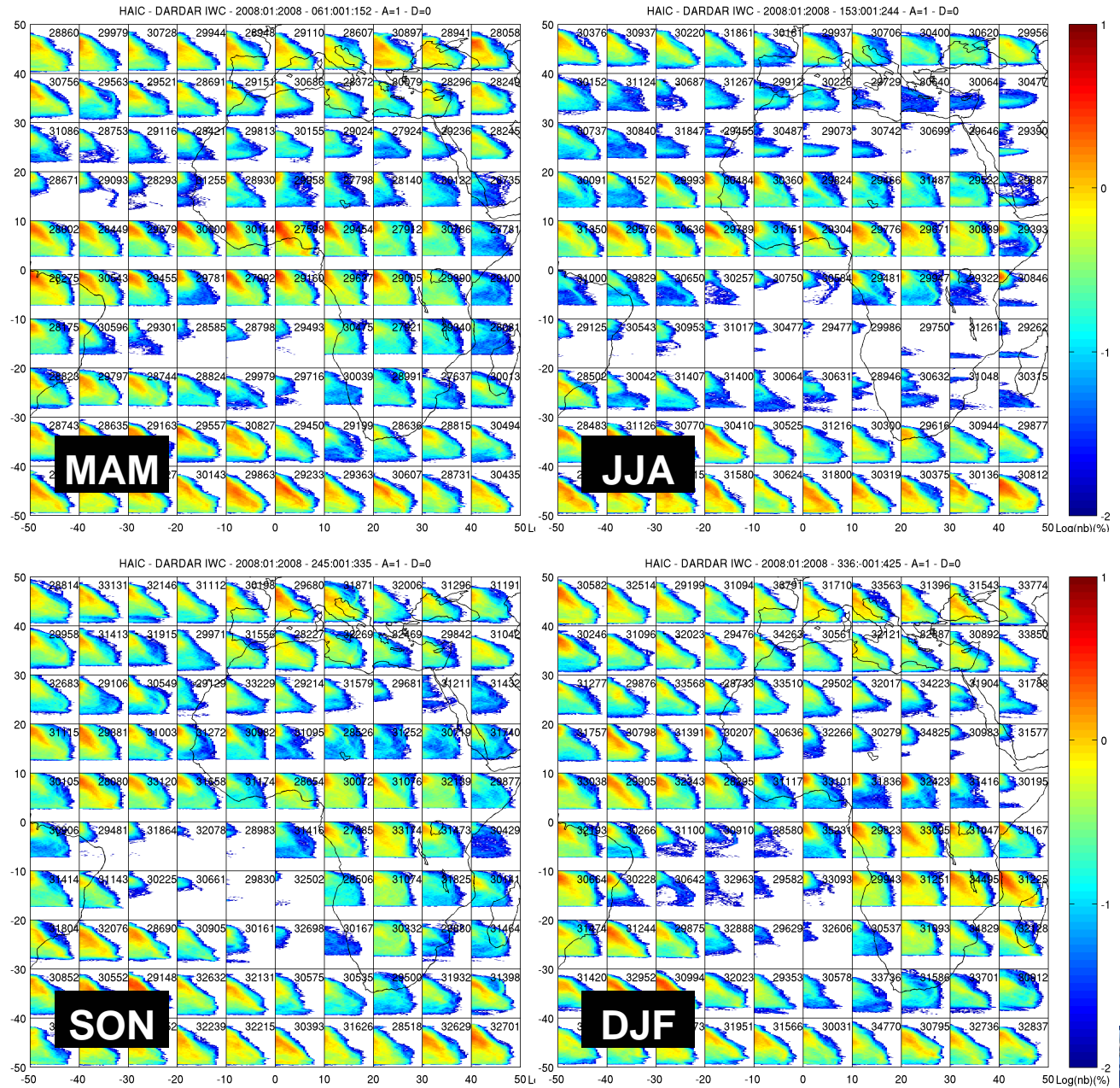
- Preliminary IWC-Height distribution for 2008 over SEVIRI domain computed per  $10^\circ \times 10^\circ$  region
- Consistent DARDAR IWC retrieval relative to RASTA IWC retrieval at high altitude (J. Delanoë, yesterday talk)



# SP3 Technical Achievements Focus

## High IWC Climatology from DARDAR (2/2)

- Year 2008;  
10° x10°
- SEVIRI domain
- Seasonal and regional variations as expected

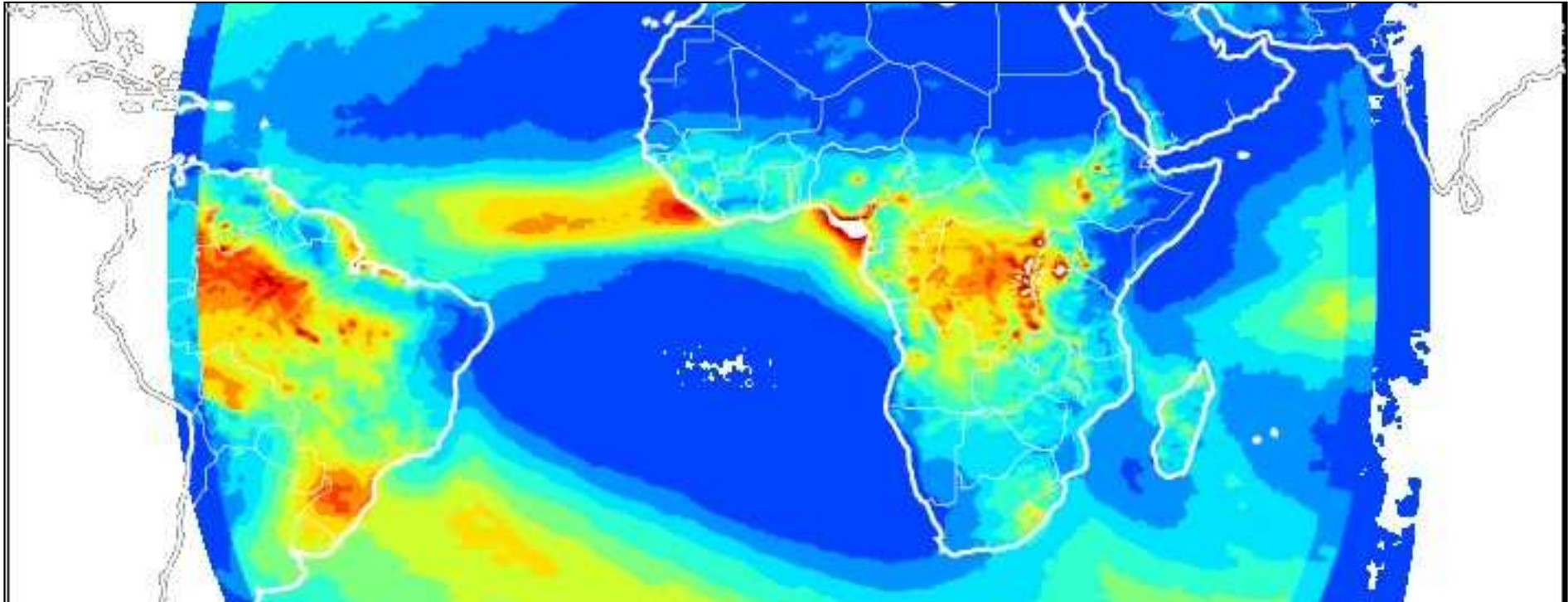




# SP3 Technical Achievements Focus

## Preliminary High IWC Climatology from KNMI High IWC Mask

**2004-2014 MSG-CPP HIWC mask climatology (colors = number of occurrences)**



*# switches between MSG 8/9/10 = different sub-satellite points – cause “bands” at edge of SEVIRI disc*

# Summary and Way Forward

- Development of analysis methodologies and detailed satellite data investigations through a multiple-approach methodology
- Unprecedented campaign data for verification and validation
- MSG-SEVIRI based high IWC mask and RDT shown to provide valuable information
- High IWC mask and RDT operationally available and successfully applied during HAIC-2016 campaign → Validation under way → On a good track for TRL6 → Toward a global scale monitoring
- Still work to do on the analysis of LEO observations → Toward a LEO-GEO synergetic product
- First evaluation of SP3 products performed with preliminary in situ dataset → Looking forward for updated in situ and airborne remote sensing observations → Feedback to other HAIC SPs and HIWC Community
- Strength and Weakness analysis to perform → inputs for follow-on project(s) and future collaborations

## High Altitude Ice Crystals (HAIC, 314314)

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