

Réunion GdR Micro-ondes
17 Avril 2014

Journée thématique Nuages de glace

Observations micro-ondes, millimétriques et sub-millimétriques: les perspectives

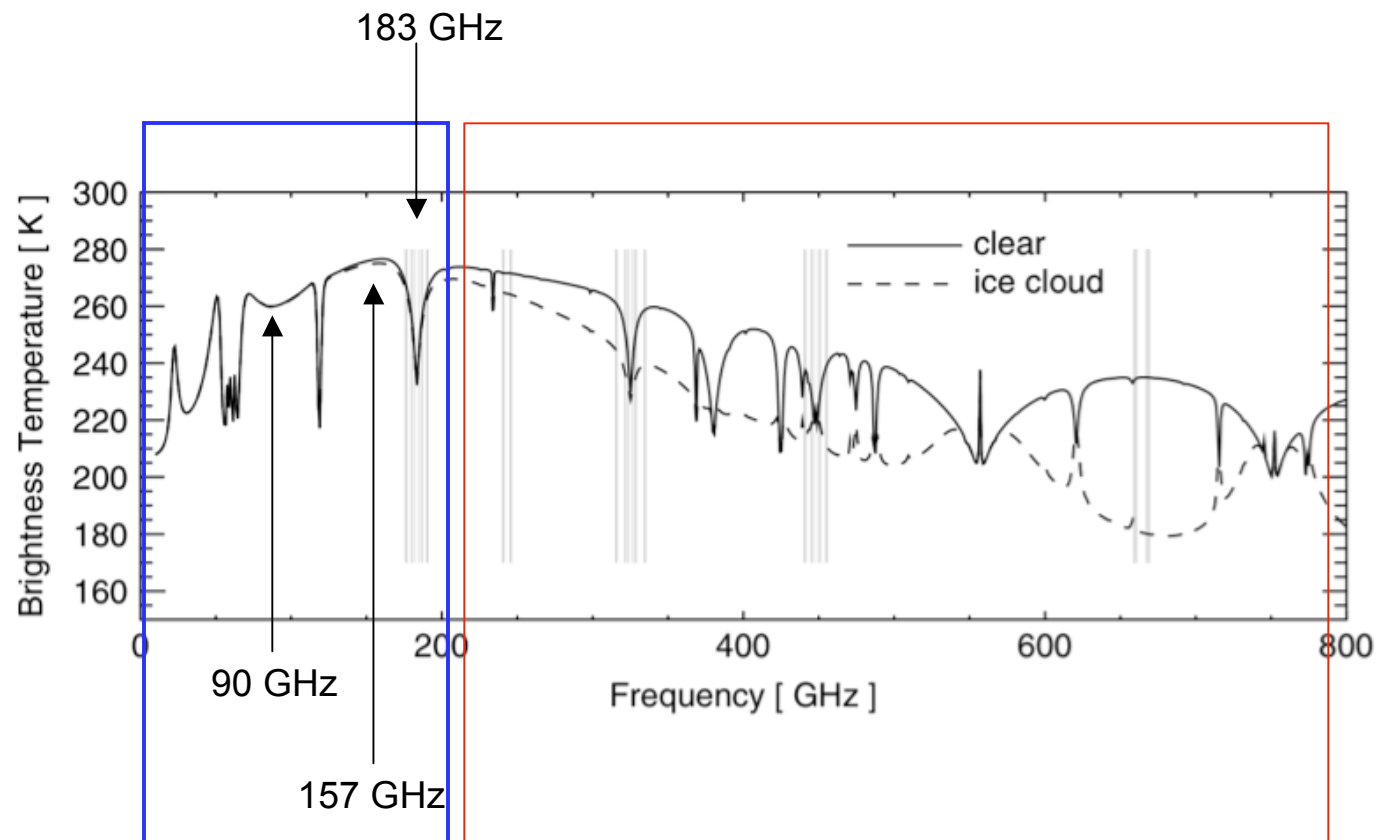
LERMA – CNRS / Observatoire de Paris (France)

Plan

- Radiométrie sub-millimétrique
- Missions en vol
- Missions à venir : METOP-SG
- Instruments aéroportés
- Exploitation des données TRMM, MT, A-Train
- En résumé

Radiométrie sub-millimétrique

- Caractérisation des nuages de glace et de la pluie par radiométrie passive multi-canaux grâce à la diffusion par la glace
- Domaine spectral : 200–900 GHz
- Sonde à travers le nuage plus ou moins profondément



Adapté de Buehler et al (2007)

Missions en vol (1/3)

Instrument & agency (& any partners)	Missions	Status	Type	Measurements & applications	Technical characteristics
AMSR-E Advanced Microwave Scanning Radiometer-EOS JAXA (NASA)	Aqua	Operational	Imaging multi-spectral radiometers (passive microwave)	Measurements of water vapour, cloud liquid water, precipitation, winds, sea surface temperature, sea ice concentration, snow cover and soil moisture	Waveband: Microwave: 6.925 GHz, 10.65 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, 89.0 GHz Spatial resolution: 5 - 50 km (dependent on frequency) Swath width: 1445 km Accuracy: Sea surface temperature: 0.5 K, Sea ice cover: 10%, Cloud liquid water: 0.05 kg/m ² , Precipitation rate: 10%, Water vapour: 3.5 kg/m ² through total column, Sea surface wind speed 1.5 m/s
AMSU-A Advanced Microwave Sounding Unit-A NASA	Aqua	Operational	Atmospheric temperature and humidity sounders	All-weather night-day temperature sounding to an altitude of 45 km	Waveband: Microwave: 15 channels, 23.8 - 89.0 GHz Spatial resolution: 48 km Swath width: 2054 km Accuracy: Temperature profile: 2 K, humidity: 3 kg/m ² , ice & snow cover: 10%
AMSU-A Advanced Microwave Sounding Unit-A NOAA (BNSC)	Metop-A, Metop-B, Metop-C, NOAA-15, NOAA-16, NOAA-17, NOAA-18	Operational	Atmospheric temperature and humidity sounders	All-weather night-day temperature sounding to an altitude of 45 km	Waveband: Microwave: 15 channels, 23.8 - 89.0 GHz Spatial resolution: 48 km Swath width: 2054 km Accuracy: Temperature profile: 2 K, humidity: 3 kg/m ² , ice & snow cover: 10%
AMSU-B Advanced Microwave Sounding Unit-B NOAA (BNSC)	NOAA-15, NOAA-16, NOAA-17	Operational	Atmospheric temperature and humidity sounders	All-weather night-day humidity sounding	Waveband: Microwave: 89 GHz, 150 GHz, 183.3±1.0 GHz (2bands), 183.3±3.0 GHz (2bands), 183.3±7.0 GHz (2bands) Spatial resolution: 16 km Swath width: 2200 km Accuracy: Humidity profile: 1 kg/m ² ,
CPR (CloudSat) Cloud Profiling Radar NASA	CloudSat	Operational	Cloud profile and rain radars	Primary goal to provide data needed to evaluate and improve the way clouds are represented in global climate models. Measures vertical profile of clouds	Waveband: Microwave: 94 GHz Spatial resolution: Vertical: 500 m, Cross-track: 1.4 km, Along-track: 2.5 km Swath width: Instantaneous Footprint < 2 km Accuracy: detects ice clouds optical depth >1, water clouds optical depth >3, ice content to +100%, -50%, liquid content to <50%, in-cloud heating to within 1K day ⁻¹ km ⁻¹
DPR Dual-frequency Precipitation Radar JAXA	GPM Core	Being developed	Cloud profile and rain radars	Measures precipitation rate classified by rain and snow, in latitudes up to 65 degrees.	Waveband: Microwave: 13.6 GHz (Ku band) and 35.5 GHz (Ka band) Spatial resolution: Range resolution: 5 km Horizontal Swath width: 245 km (Ku-band), 125 km (Ka band) Accuracy: Rainfall rate 0.2 mm/h
GMI GPM Microwave Imager NASA	GPM Constellation, GPM Core	Being developed	Imaging multi-spectral radiometers (passive microwave)	Measures rainfall rates over oceans and land, combined rainfall structure and surface rainfall rates with associated latent heating. Used to produce three hour, daily, and monthly total rainfall maps over oceans and land.	Waveband: Microwave: 10.65 GHz, 19.4 GHz, 21.3 GHz, 37 GHz, and 85.5 GHz Spatial resolution: Horizontal: 36 km cross-track at 10.65 GHz (required - Primary Spacecraft, goal - Constellation Spacecraft); 10 km along-track and cross-track (goal - Primary Spacecraft) Swath width: 800 km (Primary Spacecraft) 1300 km (Constellation Spacecraft) Accuracy: NEPT 0.5 K, 1.0 K
HSB Humidity Sounder/Brazil INPE (NASA)	Aqua	No longer operational	Atmospheric temperature and humidity sounders	Humidity soundings for climatological and atmospheric dynamics applications	Waveband: Microwave: 5 discreet channels in the range of 150-183 MHz Spatial resolution: 13.5 km Swath width: 1650 km Accuracy: Temperature: 1.0-1.2 K coverage of land and ocean surfaces, Humidity: 20%
IMWAS Improved MicroWave Atmospheric Sounder NRSCC (CAST)	FY-3C, FY-3D, FY-3E, FY-3F, FY-3G	Operational	Atmospheric temperature and humidity sounders	Atmospheric sounding measurements	Waveband: Microwave: 19.35 - 89.0 GHz (8 channels) Spatial resolution: Swath width: Accuracy:

[The Earth observation handbook, 2010]

Missions en vol (2/3)

Instrument & agency (& any partners)	Missions	Status	Type	Measurements & applications	Technical characteristics
MADRAS Microwave Analysis and Detection of Rain and Atmospheric Structures ISRO (CNES)	MEGHA-TROPIQUES	Being developed	Imaging multi-spectral radiometers (passive microwave)	To estimate rainfall, atmospheric water parameters and ocean surface winds in the equatorial belt	Waveband: 18.7 GHz, 23.8 GHz, 36.5 GHz, 89 GHz, 157 GHz Spatial resolution: 40 km Swath width: 1700 km Accuracy:
MHS Microwave Humidity Sounder EUMETSAT	Metop-A, Metop-B, Metop-C, NOAA-18, NOAA-19	Operational	Atmospheric temperature and humidity sounders	Atmospheric humidity profiles, cloud cover, cloud liquid, water content, ice boundaries and precipitation data	Waveband: Microwave: 89 GHz, 166 GHz and 3 channels near 183 GHz Spatial resolution: Vertical: 3 - 7 km, Horizontal: 30 - 50 km Swath width: 1650 km Accuracy: Cloud water profile: 10 g/m ² , specific humidity profile: 10 - 20%
MLS (EOS-Aura) Microwave Limb Sounder (EOS-Aura) NASA	Aura	Operational	Atmospheric temperature and humidity sounders	Measures lower stratospheric temperature and concentration of H ₂ O, O ₃ , ClO, HCl, OH, HNO ₃ , N ₂ O and SO ₂	Waveband: Microwave: 118 GHz, 190 GHz, 240 GHz, 640 GHz and 2.5 THz Spatial resolution: 3 x 300 km horizontal x 1.2 km vertical Swath width: Limb scan 2.5 - 62.5 km Limb to limb Accuracy: Temperature: 4 K, Ozone: 50%
MWAS MicroWave Atmospheric Sounder NRSCC (CAST)	FY-3A, FY-3B	Operational	Atmospheric temperature and humidity sounders	Meteorological applications	Waveband: Microwave: 19.35 - 89.0 GHz (8 channels) Spatial resolution: Swath width: Accuracy:
MWHS MicroWave Humidity Sounder NRSCC (CAST)	FY-3A, FY-3B, FY-3C, FY-3D, FY-3E, FY-3F, FY-3G	Operational	Atmospheric temperature and humidity sounders	Meteorological applications	Waveband: Microwave: 19.35 - 89.0 GHz (8 channels) Spatial resolution: 15 km at media, 41 x 27 km at outer edge Swath width: 2700 km Accuracy: 15 km
MWRI MicroWave Radiation Imager NRSCC (CAST)	FY-3A, FY-3B, FY-3C, FY-3D, FY-3E, FY-3F, FY-3G	Operational	Imaging multi-spectral radiometers (passive microwave)	All weather observations of precipitation, cloud features, vegetation, soil moisture, sea ice, etc.	Waveband: 12 channels, 6 frequencies: 10.65 GHz, 18.7 GHz, 23.8 GHz, 36.5 GHz, 89 GHz, 150 GHz Spatial resolution: 7.5 x 12 km at 150 GHz to 51 x 85 km at 10.65 GHz Swath width: 1400 km Accuracy:
MWTS Microwave Temperature Sounder NRSCC	FY-3A, FY-3B, FY-3C, FY-3D, FY-3E, FY-3F, FY-3G	Operational	Atmospheric temperature and humidity sounders	Temperature sounding in nearly all weather conditions	Waveband: 50.3 GHz, 53.6 GHz, 54.94 GHz, 57.29 GHz Spatial resolution: 62 km Swath width: 750-1125km Accuracy: 50-75Kkm
PR Precipitation Radar JAXA (NASA)	TRMM	Operational	Cloud profile and rain radars	Measures precipitation rate in tropical latitudes	Waveband: Microwave: 13.796 GHz and 13.802 GHz Spatial resolution: Range resolution: 250 m Horizontal resolution: 4.3 km at nadir (post-boost: 5km) Swath width: 215 km (post-boost: 245 km) Observable range: from surface to approx 15 km altitude Accuracy: Rainfall rate 0.7 mm/h at storm top
SAPHIR Sondeur Atmospherique du Profil d'Humidite Intertropicale par Radiometrie CNES	MEGHA-TROPIQUES	Being developed	Atmospheric temperature and humidity sounders	Cross-track sounder with the objective of measuring water vapour profiles in the troposphere in six layers from 2-12km altitudes.	Waveband: Microwave: 183.3 GHz (6 channels) Spatial resolution: 10 km Swath width: 2200 km Accuracy:

[The Earth observation handbook, 2010]

Missions en vol (3/3)

Instrument & agency (& any partners)	Missions	Status	Type	Measurements & applications	Technical characteristics
SMILES Superconducting Submillimeter-Wave Limb-Emission Sounder JAXA	ISS/JEM	Operational	Atmospheric chemistry	High-sensitivity observation of stratospheric minor gases related to ozone depletion	Waveband: 624.32 - 625.52GHz, 625.12 - 626.32GHz, 649.12 - 650.32GHz Spatial resolution: Swath width: Accuracy: O3: less than 5%(15-60km), 1%(~30km) HCl: less than 10%(15-50%) ClO: less than 30%(25-50km)
SMR Submillimetre Radiometer SNSB	Odin	Operational	Atmospheric temperature and humidity sounders and atmospheric chemistry	Measures global distributions of ozone and species of importance for ozone chemistry, ClO, HNO3, H2O, N2O, (HO2, H2O2). Measures temperature in the height range 15-100km.	Waveband: Microwave: 118.7 GHz + 4 bands in the region 480 - 580 GHz; Tunable measures 2 - 3 x 1 GHz regions at a time; ~0.1 cm - ~0.3 cm Spatial resolution: Vertical resolution 1.5 - 3 km, along track 600 km Swath width: Altitudes of 5 - 100 km Accuracy: 2 - 40% depending on species and altitude
SSM/I Special Sensor Microwave Imager NOAA (DoD (USA))	DMSP F-14, DMSP F-15	Operational	Imaging multi-spectral radiometers (passive microwave)	Measures atmospheric, ocean and terrain microwave brightness temperatures to provide: sea surface winds, rain rates, cloud water, precipitation, soil moisture, ice edge, ice age.	Waveband: Microwave: 19.35 GHz, 22.235 GHz, 37 GHz, 85 GHz Spatial resolution: 15.7 x 13.9 km to 68.9 x 44.3 km (depends on frequency) Swath width: 1400 km Accuracy:
SSM/IS Special Sensor Microwave Imager Sounder NOAA (DoD (USA))	DMSP F-16, DMSP F-17, DMSP F-18, DMSP F-19, DMSP F-20	Operational	Atmospheric temperature and humidity sounders	Measures thermal microwave radiation. Global measurements of air temp profile, humidity profile, ocean surface winds, rain overland/ocean, ice concentration/age, ice/snow edge, water vapour/clouds over ocean, snow water content, land surface temperature.	Waveband: Microwave: 19 - 183 GHz (24 frequencies) Spatial resolution: Varies with frequency: 25 x 17 km to 70 x 42 km Swath width: 1700 km Accuracy:
SSM/T-1 Special Sensor Microwave Temperature Sounder NOAA (DoD (USA))	DMSP F-14, DMSP F-15	Operational	Atmospheric temperature and humidity sounders	Measures Earth's surface and atmospheric emission in the 50 - 60 GHz oxygen band	Waveband: Microwave: 7 channels in the 50 - 60 GHz range Spatial resolution: 174 km diameter beam Swath width: 1500 km Accuracy:
SSM/T-2 Special Sensor Microwave Water Vapor Sounder NOAA (DoD (USA)) TMI TRMM Microwave Imager NASA	DMSP F-14, DMSP F-15 TRMM	Operational Operational	Atmospheric temperature and humidity sounders Imaging multi-spectral radiometers (passive microwave)	Water vapour profiler Measures rainfall rates over oceans (less reliable over land), combined rainfall structure and surface rainfall rates with associated latent heating. Used to produce monthly total rainfall maps over oceans	Waveband: Microwave: 91.6, 150, 183.31 (3 channels) (Total 5 channels) Spatial resolution: Approx 48 km Swath width: 1500 km Accuracy: Waveband: Microwave: 10.7 GHz, 19.4 GHz, 21.3 GHz, 37 GHz, and 85.5 GHz Spatial resolution: Vertical: 2.5 km approx; Horizontal: 18 km Swath width: 790 km Accuracy: Liquid water: 3 mg/cm3, Humidity: 3 mg/cm3, Ocean wind speed: 1.5 m/s

[The Earth observation handbook, 2010]

Missions à venir (1/2)

- METOP-SG**

	MetOp-SG-A	MetOp-SG-B
Launch	~2020	~2021
Orbit, altitude	SSO, 817 km	SSO, 817 km
S/C mass	~3000 kg	~2400 kg
Lifetime	8.5 years	8.5 years
Sensor complement	8 instruments	7 instruments
	METImage (DLR)	MWI (Microwave Imaging Radiometer), (ESA)
	MWS (Microwave Sounder), (ESA)	ICI (Ice Cloud Imager), (ESA)
	IASI-NG (Infrared Atmospheric Sounder Interferometer-Next Generation), (CNES)	SCA (Scatterometer), (ESA)
	RO (Radio Occultation), (ESA)	RO (Radio Occultation), (ESA)
	3MI (Multi-view Multi-channel Multi-polarization Imager), (ESA)	Argos-4 (Data Collection Service) (NOAA/CNES)
	Radiation Energy Radiometer (NOAA)	Search and Rescue (COSPAS-SARSAT)
	UVNS/Sentinel-5 (ESA/Copernicus)	Space Environment Monitor (NOAA)
	Low Light Imager (NOAA)	

Channel No	Frequency (GHz)	Utilization	NEAT (K)
MWS-1	23.8	Water-vapor column	0.3
MWS-2	31.4	Window, water-vapor column	
MWS-3	50.3	Quasi-window, surface emissivity	
MWS-4	52.8	Temperature profile	
MWS-5	53.246±0.08		
MWS-6	53.596±0.115		
MWS-7	53.948±0.081		
MWS-8	54.4		
MWS-9	54.94		
MWS-10	55.5		
MWS-11	57.290344		0.5
MWS-12	57.290344±0.217		0.5
MWS-13	57.290344±0.3222±0.048		0.8
MWS-14	57.290344±0.3222±0.022		1.1
MWS-15	57.290344±0.3222±0.010		1.8
MWS-16	57.290344±0.3222±0.0045		0.2
MWS-17	89	Window	0.4
MWS-18	165.5±0.725	Quasi-window, water-vapor profile	0.35
MWS-19	183.311±7.0	Water-vapor profile, precipitation	0.35
MWS-20	183.311±4.5	Water-vapor profile	
MWS-21	183.311±3.0		
MWS-22	183.311±1.8		
MWS-23	183.311±1.0		0.5
MWS-24	229	Quasi-window, water-vapor profile	0.7
			0.5

	PARASOL/POLDER			3MI - Start of Phase A			3MI - End of Phase A		
	Center Wavelength (nm)	Width (nm)	Polarized	Center Wavelength (nm)	Width (nm)	Polarized	Center Wavelength (nm)	Width (nm)	Polarized
VNIR				354	10	Y			
				388	20	Y	410	20	Y
	443	20	N	443	20	Y	443	20	Y
	490	20	Y	490	20	Y	490	20	Y
	565	20	N	555	20	Y(G)/N(R)	555	20	Y
	670	20	Y	670	20	Y	670	20	Y
	763	10	N	763	10	N	763	10	N
	765	40	N	754(G)/765(R)	20(G)/40(R)	N	754	20	N
	865	40	Y	865	40	Y	865	40	Y
	910	20	N	910	20	N	910	20	N
	1020	20	N						
SWIR				1370	40	Y	1370	40	Y
				1650	40	Y(G)/N(R)	1650	40	Y
				2130	40	Y	2130	40	Y

Missions à venir (2/2)

- METOP-SG**

	MetOp-SG-A	MetOp-SG-B
Launch	~2020	~2021
Orbit, altitude	SSO, 817 km	SSO, 817 km
S/C mass	~3000 kg	~2400 kg
Lifetime	8.5 years	8.5 years
Sensor complement	8 instruments	7 instruments
	METImage (DLR)	MWI (Microwave Imaging Radiometer), (ESA)
	MWS (Microwave Sounder), (ESA)	ICI (Ice Cloud Imager), (ESA)
	IASI-NG (Infrared Atmospheric Sounder Interferometer-Next Generation), (CNES)	SCA (Scatterometer), (ESA)
	RO (Radio Occultation), (ESA)	RO (Radio Occultation), (ESA)
	3MI (Multi-view Multi-channel Multi-polarization Imager), (ESA)	Argos-4 (Data Collection Service) (NOAA/CNES)
	Radiation Energy Radiometer (NOAA)	Search and Rescue (COSPAS-SARSAT)
	UVNS/Sentinel-5 (ESA/Copernicus)	Space Environment Monitor (NOAA)
	Low Light Imager (NOAA)	

Channel No	Frequency (GHz)	Utilization	NEΔT (K)
MWI-1	18.7	Precipitation over sea	0.7
MWI-2	23.8	Total column water vapor over sea	0.6
MWI-3	31.4	Precipitation over sea and (marginally) land	0.8
MWI-4	50.3	Precipitation over sea and land including drizzle, snowfall, height and depth of the melting layer	0.7
MWI-5	52.61		
MWI-6	53.24		
MWI-7	53.75		
MWI-8	89	Precipitation (sea & land) & snowfall	0.8
MWI-9	118.7503±3.2	Precipitation over sea and land including light precipitation and snowfall, height and depth of the melting layer	1.2
MWI-10	118.7503±2.1		
MWI-11	118.7503±1.4		
MWI-12	118.7503±1.2		
MWI-13	165.5±0.725	Quasi-window, water-vapor profile, precipitation over land, snowfall	1.1
MWI-14	183.31±8.4	Water vapor profile and snowfall	1.0
MWI-15	183.31±6.1		1.1
MWI-16	183.31±4.9		1.1
MWI-17	183.31±3.4		1.1
MWI-18	183.31±2.0		1.2

Channel No	Frequency (GHz)	Bandwidth (GHz)	Polarization	Utilization	NEΔT (K)
ICI-1	183.31±8.4	6	V	Water vapor profile and snowfall	0.6
ICI-2	183.31±3.4	3	V		0.7
ICI-3	183.31±2.0	3	V		0.7
ICI-4	243.2±2.5	6	V, H	Quasi-window, cloud ice retrieval, cirrus clouds	0.6
ICI-5	325.15±9.5	6	V	Cloud ice effective radius	1.1
ICI-6	325.15±3.5	4.8	V		1.2
ICI-7	325.15±1.5	3.2	V		1.4
ICI-8	448±7.2	6	V	Cloud ice water path and cirrus	1.3
ICI-9	448±3.0	4	V		1.5
ICI-10	448±1.4	2.4	V		1.9
ICI-11	664±4.2	10	V, H	Quasi-window, cirrus clouds, cloud ice water path	1.5

Instrumentation aéroportée (1/3)

- **HAMP** : HALO Microwave Package (Hamburg Univ.)
 - > 3 radiometers (nadir; calibration : Dicke switch, internal ambient temperature target for 183 GHz, reference calibration with liquid nitrogen at ground; 1-s integration time; 0.9–1.4 km along track and 0.6–1.1 km cross track @ 13 km altitude)
- **MIRA-36** : Ka-Band (35.5 GHz) Doppler radar



(Courtesy Mario Mech, IGM, University of Cologne)

Band	Frequencies [GHz]	NeDT [K]	FWHM [°]
H ₂ O	22.24, 23.04, 23.84, 25.44, 26.24, 27.84, 31.40	0.1	5.0
O ₂	50.3, 51.76, 52.8, 53.75, 54.94, 56.66, 58.00	0.2	3.5
Window	90.0	0.25	3.3
O ₂	118.75±8.5, 118.75±4.2, 118.75±2.3, 118.75±1.4	0.6	3.3
H ₂ O	183.31±12.5, 183.31±7.5, 183.31±5.0, 183.31±3.5, 183.31±2.5, 183.31±1.5, 183.31±0.6	0.6	2.7

Instrumentation aéroportée (2/3)

- **ISMAR** : International Sub-Millimeter Airborne Radiometer (UK Met Office)
 - > 21 channels in a single along track instrument, nadir (zenith) scan ranges from -10° to 55° (-40° to 10°), on-board hot and cold calibration loads, integration time adjustable (1ms to 10s)
- MARSS (89 GHz (1), 157 GHz (1), 183 GHz (3))
- DEIMOS (24 GHz (1) & 50–54 GHz (5))



Band	Frequencies [GHz]	NeDT [K]	FWHM [°]
O ₂	118.75±5.0, 118.75±3.0, 118.75±2.1, 118.75±1.5, 118.75±1.1	<0.5	5.0
Window	243.2±2.5 (V, H)	<1.5	5.0
H ₂ O	325±9.5, 325±3.5, 325±1.5	<1.5	5.0
O ₂	424.7±4.0, 424.7±1.5, 424.7±1.0 (*)	<2	5.0
H ₂ O	448±7.2, 448±3.0, 448±1.0	<2	5.0
Window	664±4.2 (V, H)	<4	5.0
Window	875±cc (V, H)	<4	5.0

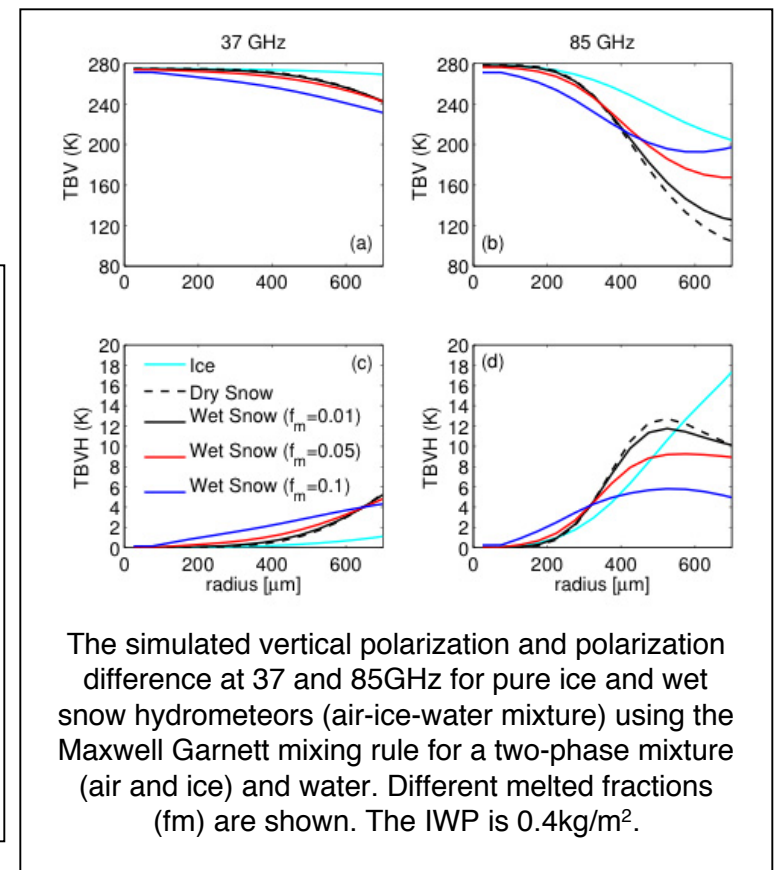
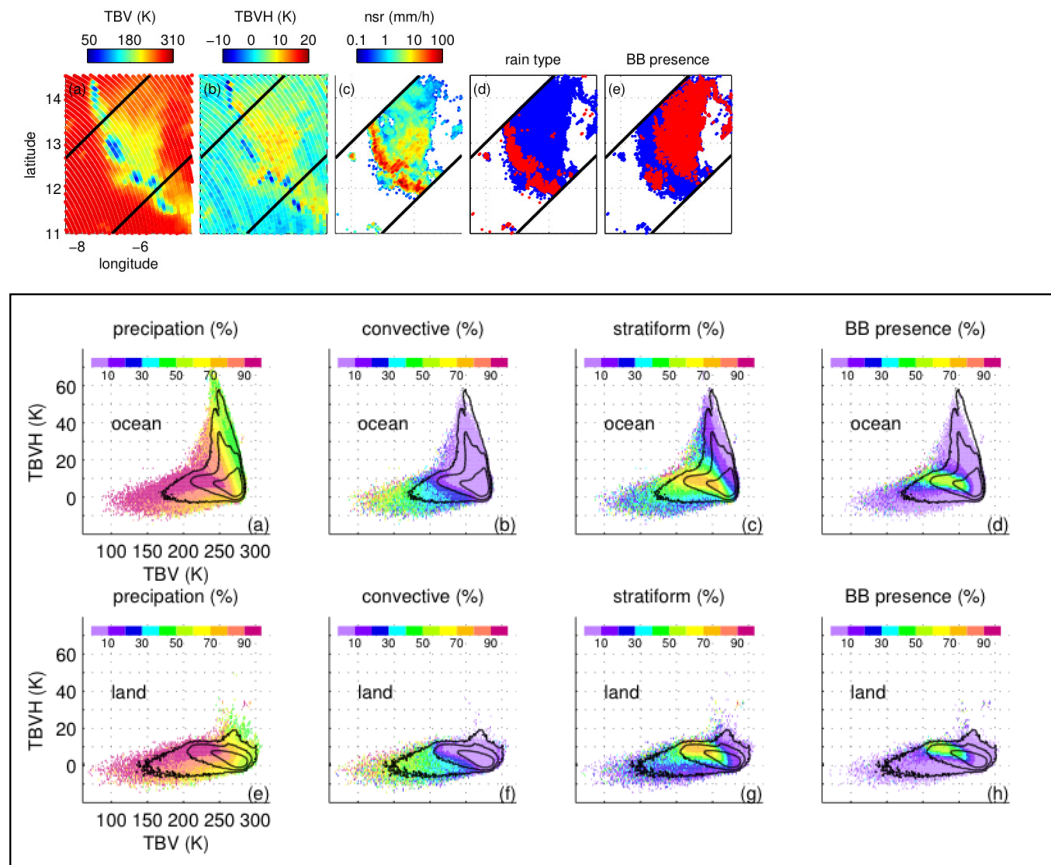
(*) Proposition de construction du LERMA (CNES-TOSCA 2015 & RT)

Instrumentation aéroportée (3/3)

- **RALI/RASTA** (J. Delanoë, LATMOS)
 - > Radar Doppler de nuage (95 GHz) sur SAFIRE F20
- **LNG** (L. Pelon, LATMOS)
 - > Lidar opérant à 355 nm, 532 nm et 1064 nm
- **OSIRIS** (F. Parol, LOA)
 - > Version aéroportée de 3MI issu de la technologie POLDER avec une gamme spectrale fortement étendue (440–940 nm; 940–2200 nm)
 - > Mesure de la luminances totale et polarisées

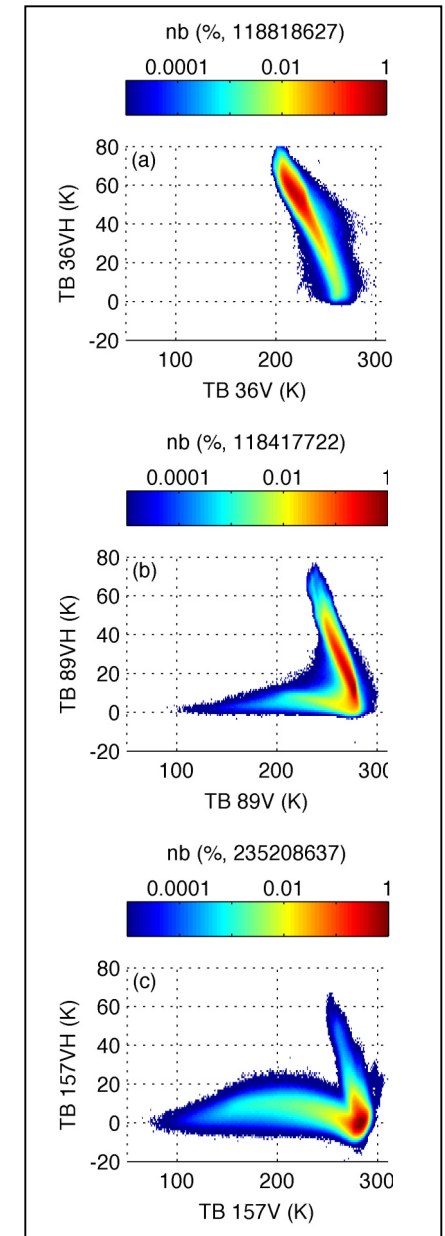
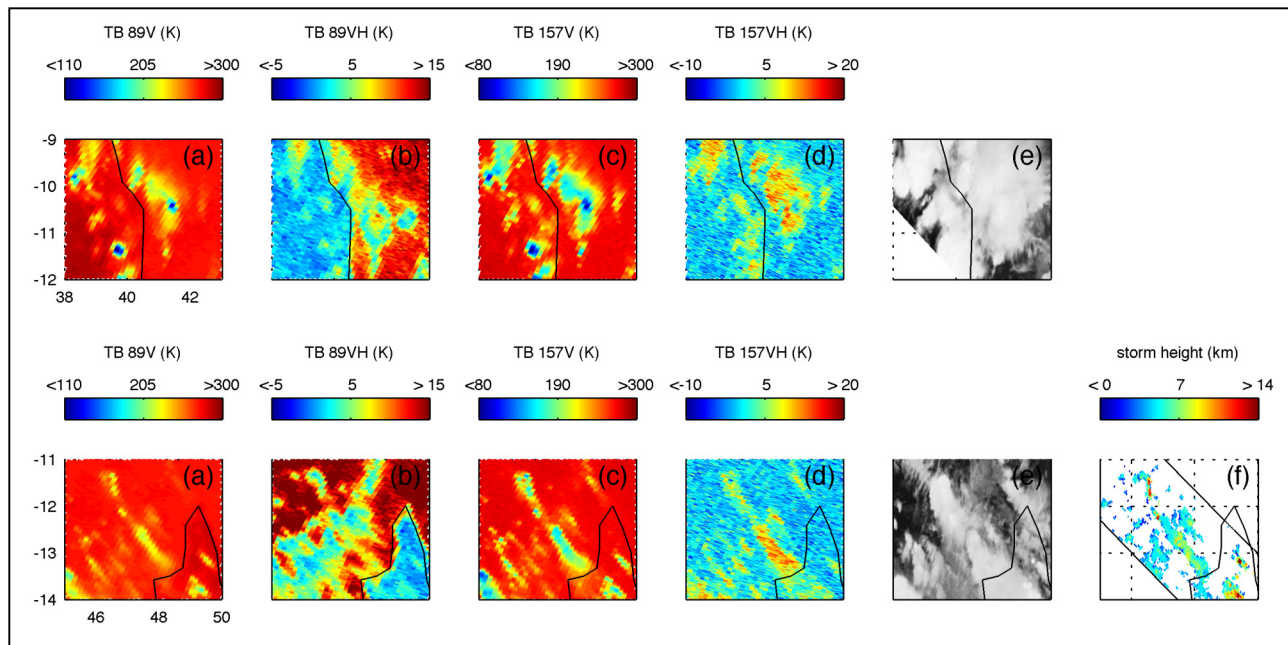
TRMM

- Interprétation des observations micro-ondes à l'aide des autres observations de TRMM (PR, LIS, VIRS) et de calculs radiatifs pour la caractérisation des régions convectives et stratiformes (e.g. Galligani et al., JGR, 2013)



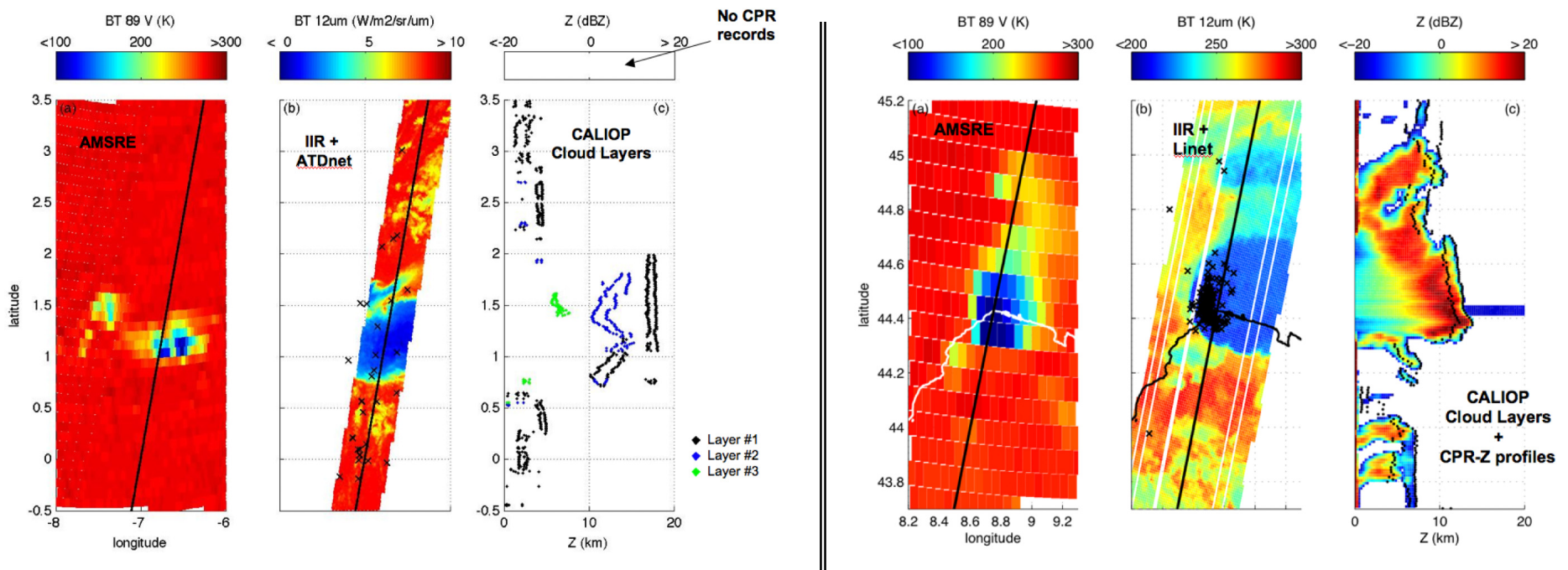
Megha-Tropiques

- Premières observations polarisées à 157 GHz
- Etude de la diffusion à 89 et 157 GHz
 - > Apporte de nouvelles contraintes en transfert radiatif et représentation de la microphysique nuageuse
- Intérêt de l'analyse d'observations coïncidentes MT, TRMM & A-Train

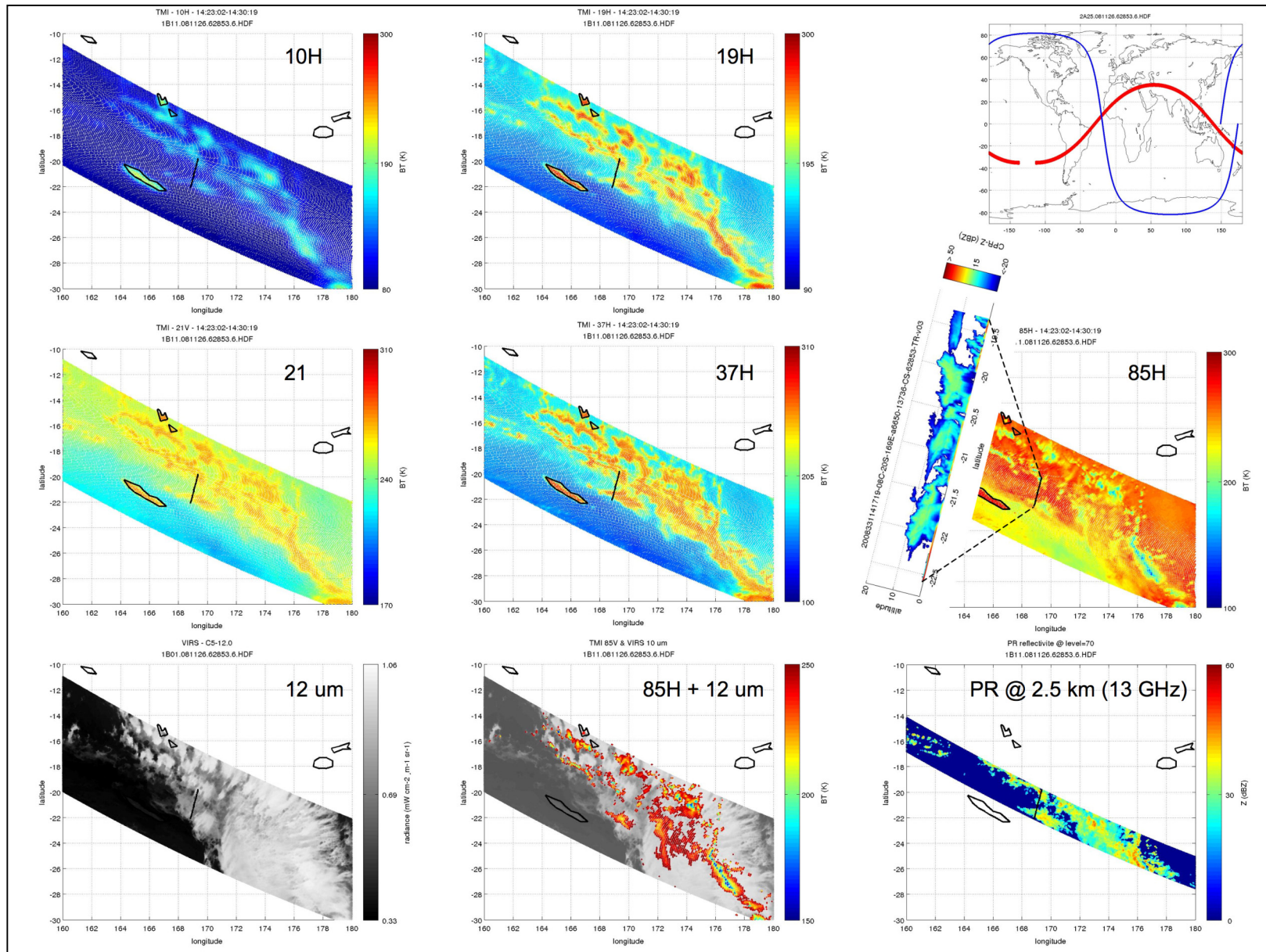


A-Train

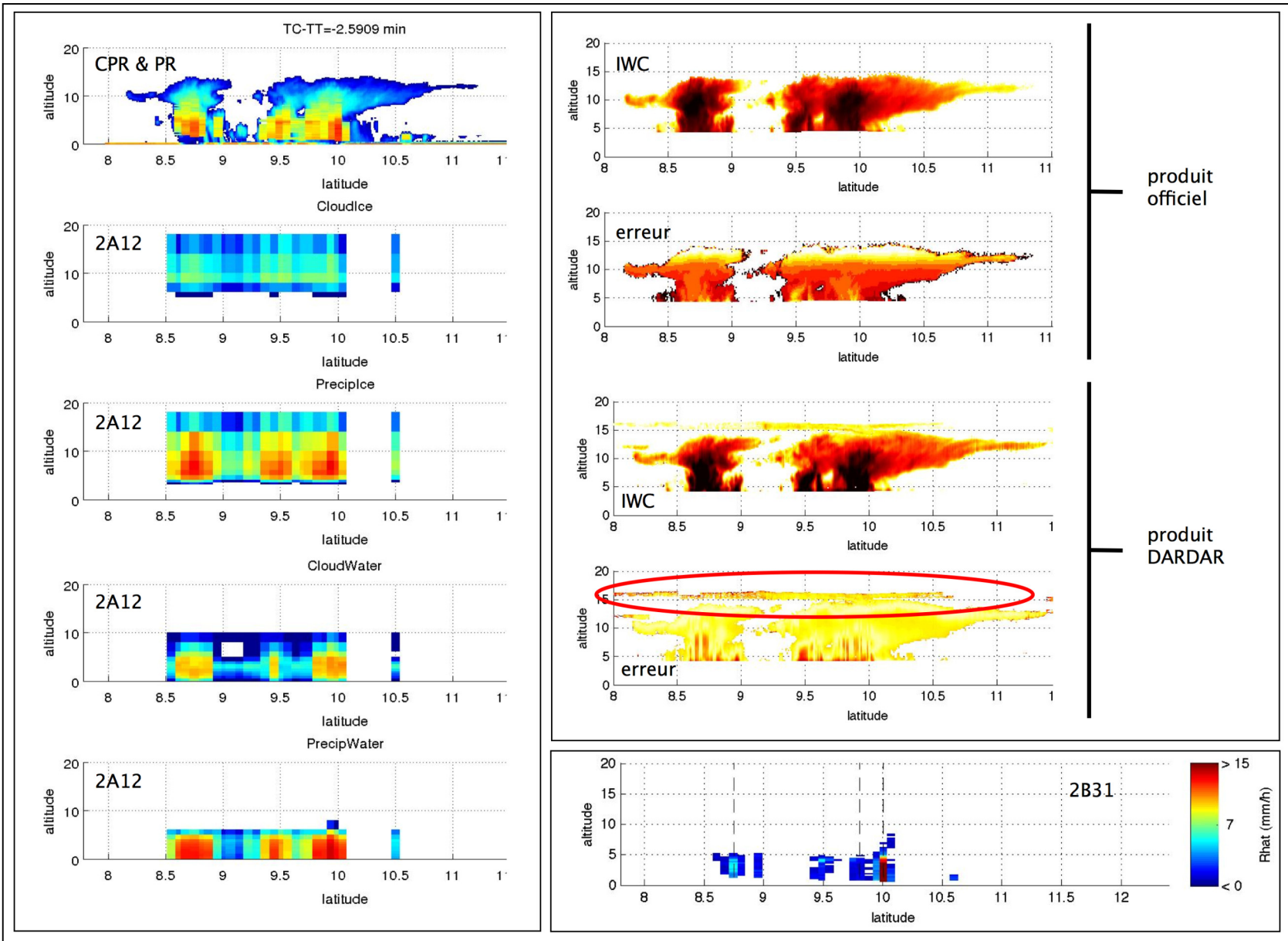
- Observations simultanées micro-ondes (actif & passif), optique et IR
- Caractérisation des nuages convectifs et épais si la donnée micro-onde est la référence
 - > Etude des processus & des propriétés des nuages
- Vérification de paramétrisation (transfert radiatif, modèle microphysique)



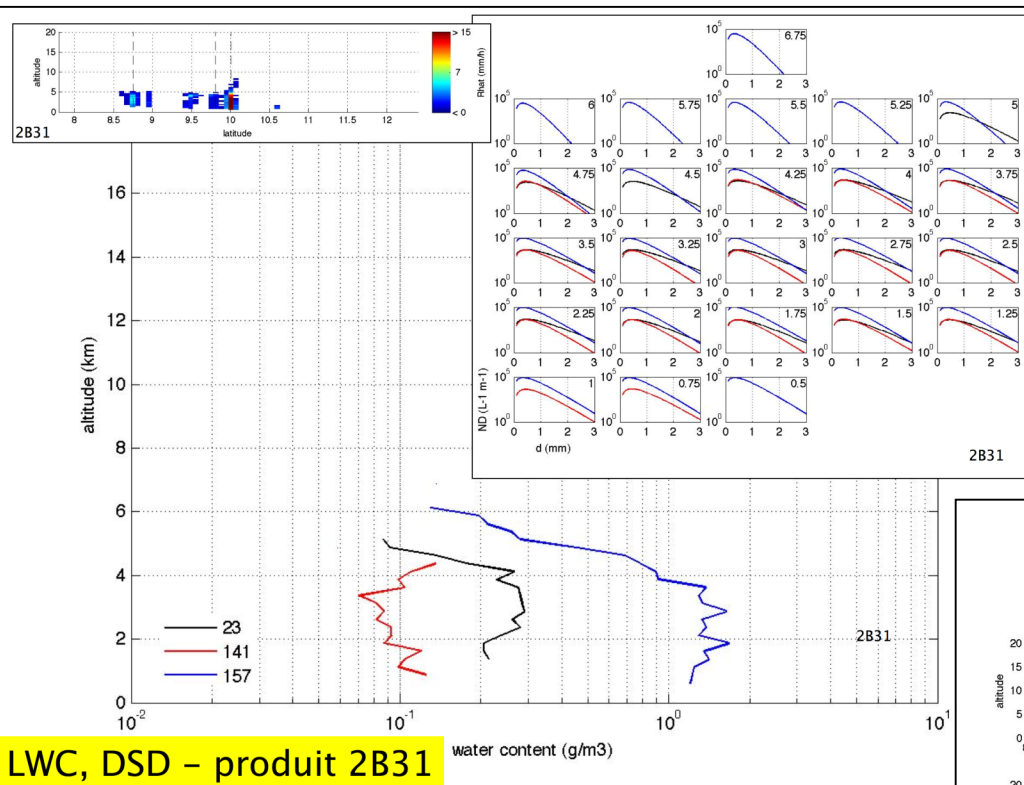
TRMM-A-Train (1/3)



TRMM-A-Train (2/3)



TRMM-A-Train (3/3)

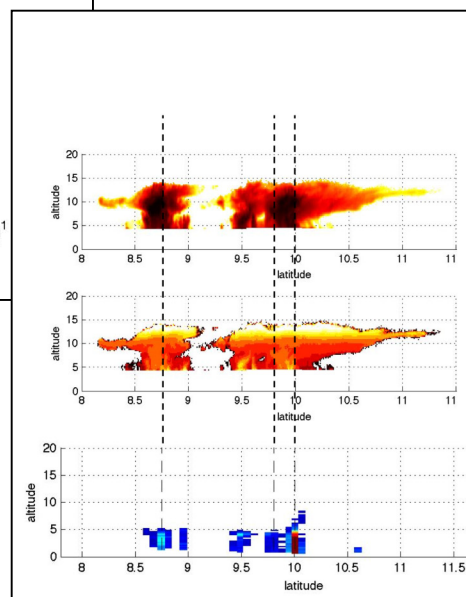


TRMM Products
 - Liquid water content (2B31)
 - DSD (2B31)

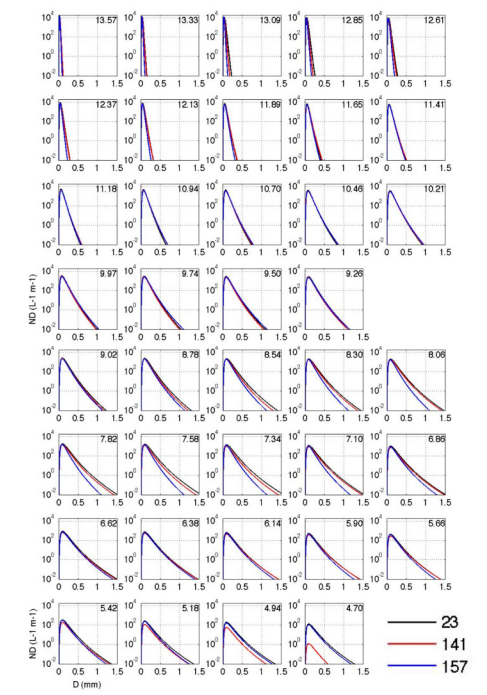
CPR Products
 - IWC
 - PSD

LWC, DSD – produit 2B31

- Quality of TRMM 2B31 product?
- Quality of CPR products in convective and thick precipitating clouds?



PSD – produit RO-CWC



En résumé

- Exploitation de données spatiales existantes à poursuivre
 - > Compréhension des observations et interprétation à l'aide d'outils de transfert radiatif
 - > Amélioration des paramétrisations (radiatif, nuage)
 - > Amélioration des produits existants
 - > Etude des processus et suivi
- Préparation aux nouvelles missions
 - > Outils de modélisation suffisants?
 - > Développement des algorithmes
 - > Etudes synergétiques à réaliser
 - > Quelle stratégie sur l'instrumentation aéroportée?