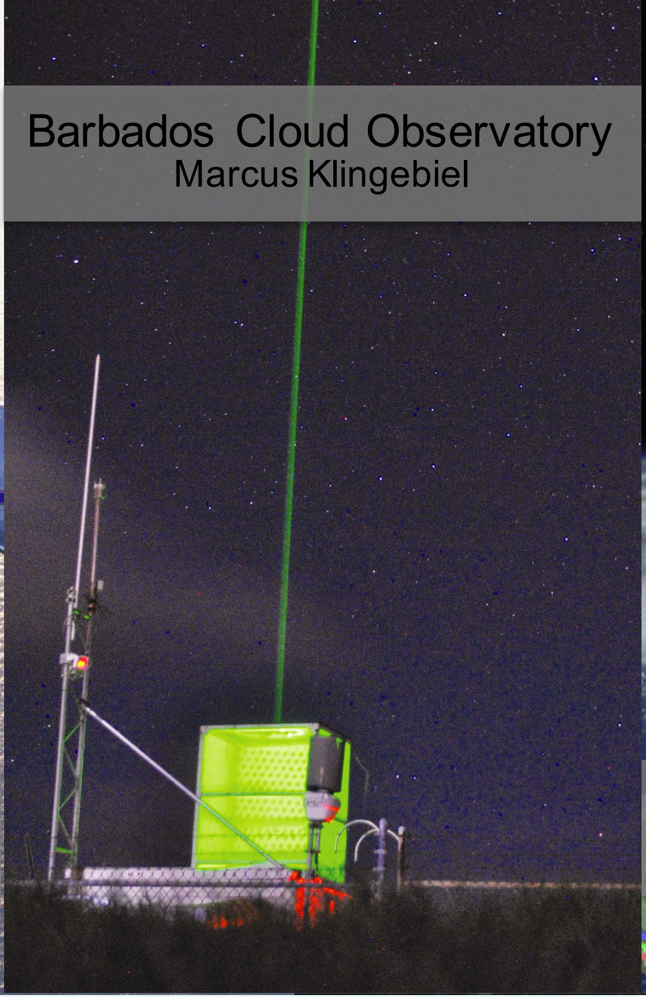
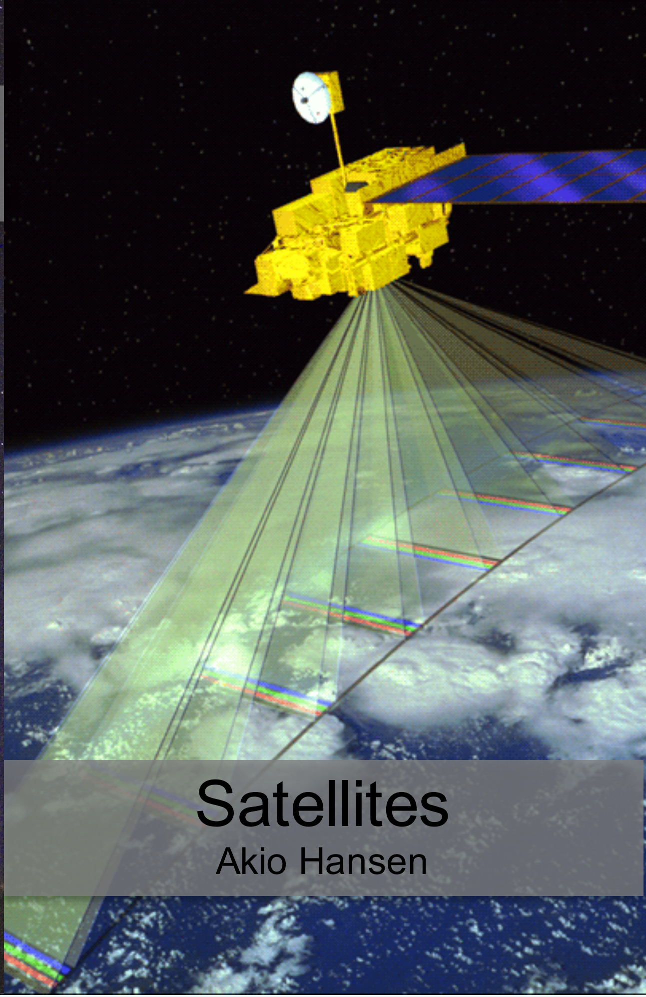

Aircrafts
Hauke Schulz


Barbados Cloud Observatory
Marcus Klingebiel

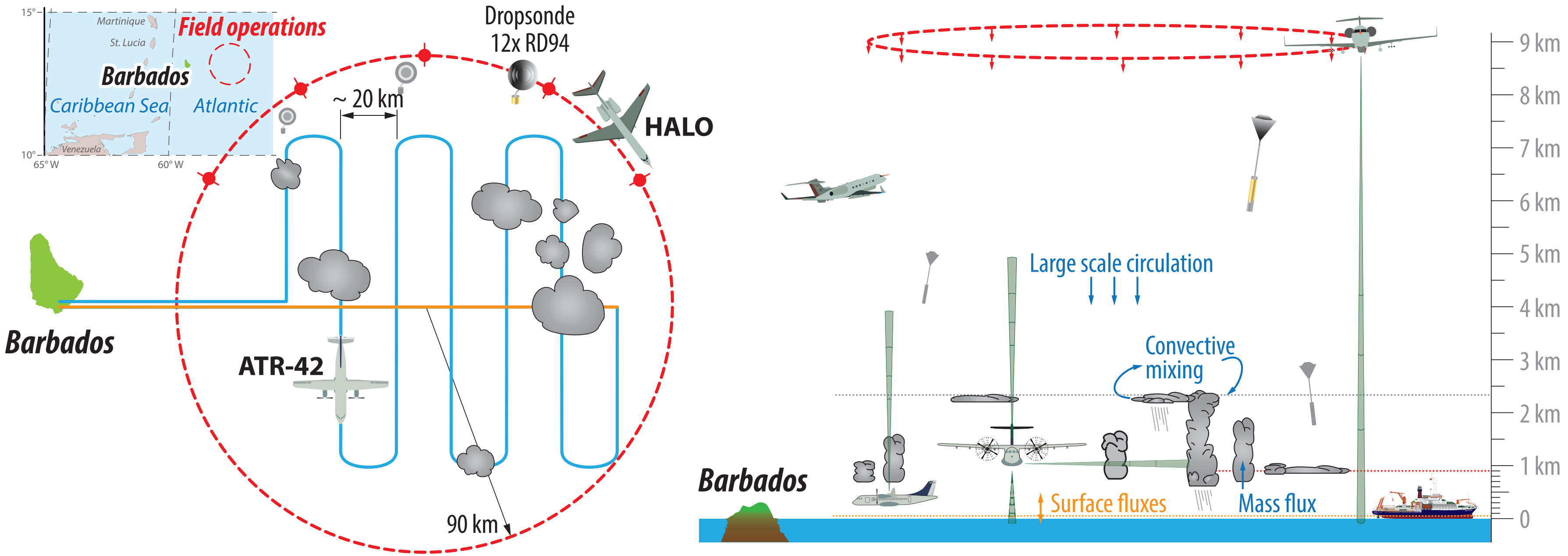

Satellites
Akio Hansen

EUREC^{4}A primary objectives

- Quantification of macrophysical properties of trade-wind cumuli as a function of the large-scale environment

- Production of a reference data set that may be used as a benchmark for the modelling and the satellite observation of shallow clouds and circulation

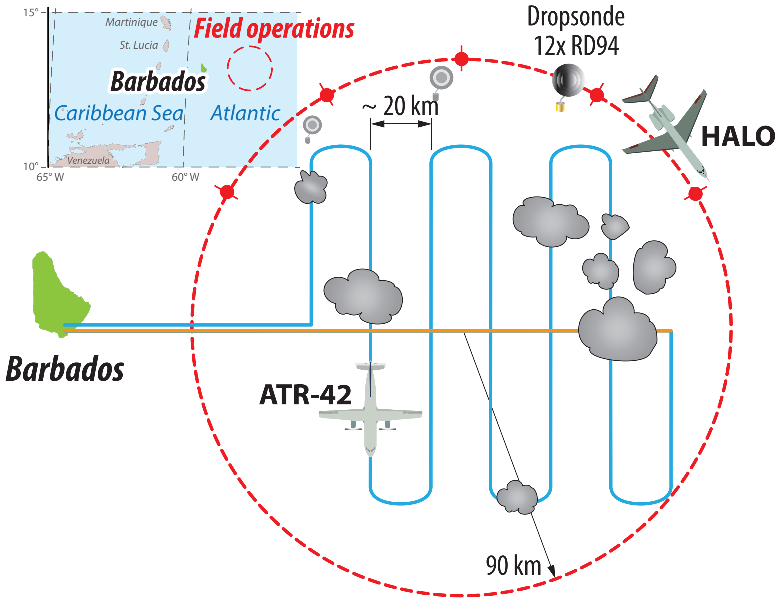
EUREC^{4}A sampling strategy



Bony, S.; Stevens, B.; Ament, F.; et al. EUREC4A: A Field Campaign to Elucidate the Couplings Between Clouds, Convection and Circulation. *Surv Geophys* **2017**, *38* (6), 1529--1568.

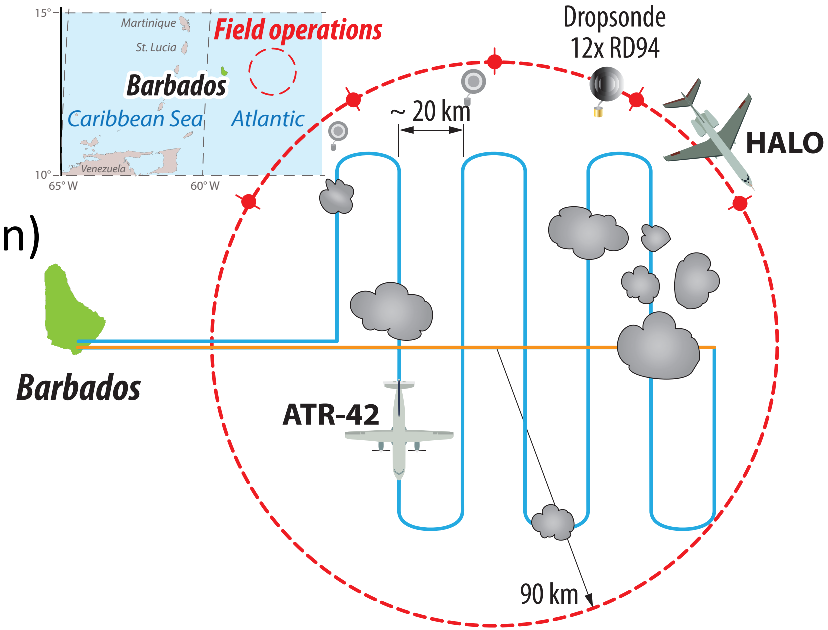
EUREC^{4}A flight schedule

- HALO will characterize the cloud macroscopic conditions and its large-scale environment with remote sensing instruments and dropsondes
- HALO's advanced array of remote sensing will inform reconstruction of microphysical structure and aerosol environment
- ATR-42 will provide first measurements of the vertical cloud profile in a well constrained large-scale environment using upward and sideward looking radar, and sideward looking lidar
- ATR-42 will characterize the shallow cumulus field and boundary-layer properties within the circled area
- ATR-42 flies primarily at cloud base, but additional flights near the surface and near the inversion layer will record turbulence and state variables
- Additional planes will contribute with microphysical measurements or characterization of the meso-scale environment depending on instrumentation and flight-range



EUREC⁴A flight schedule

HALO ferry flight	18.1.2020
Flights per week	3; every other day (1 daytime, 1 dusk, 1 dawn)
Flight time	HALO: 1x 9 hrs ATR-42: 2x 4hrs
HALO return flight	20./21.2. or 15./16.2. depending on project following EUREC⁴A



Planes, planes and more planes

HALO

NOAA G-IV

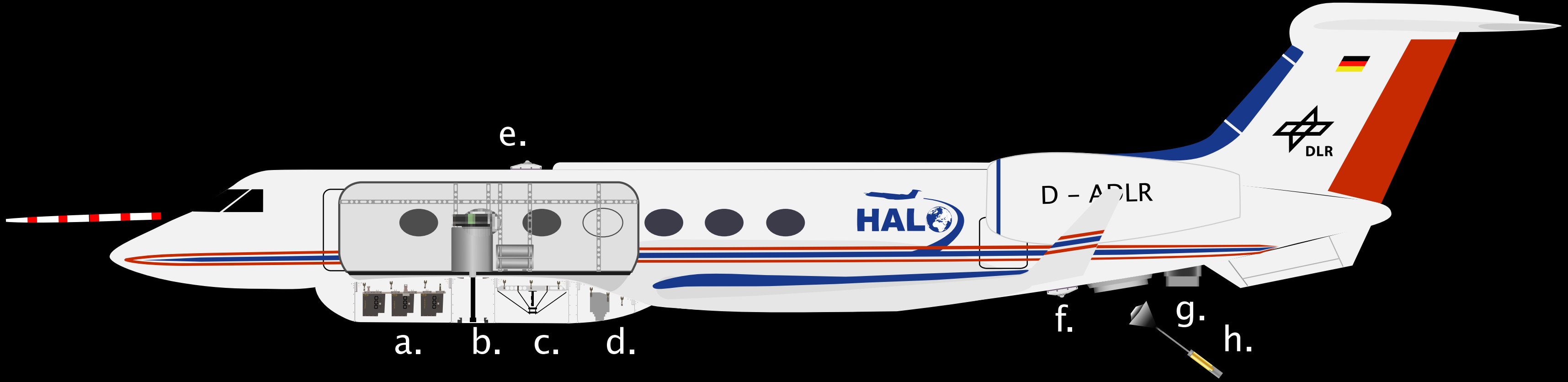
NOAA P3

ATR-42

BAS Twin Otter

NOAA Twin Otter

HALO – High altitude long range research aircraft



Belly Pod Section

a. Radiometer Bank
b. Water Vapour DIAL (WALES)
c. Cloud and Precipitation Radar
d. Thermal Imager
e. SMART

Tail Section

f. SMART
g. specMACS
h. Dropsondes

Stevens, B.; Ament, F.; Bony, S. et al. A High-Altitude Long-Range Aircraft Configured as a Cloud Observatory–the NARVAL Expeditions. *Bull. Amer. Meteor. Soc.* **2019**.

HALO

Instrument	Description	Derived products
HAMP cloud radar	- Brightness temperature at 26 selected microwave frequencies between 22 and 183 GHz - Profiles of radar reflectivity, depolarization ratio & Doppler velocity	- Integ. Water vapor - Temperature & humidity profiles - Cloud-, snow-, rain- water path - Target classification, cloud geometry, rain rate
HAMP radiometer	- Broadband down- and upwelling solar- and thermal- infrared irradiance	- Cloud radiative forcing (CRF)
WALES lidar	Profiles of: Backscatter coefficient, Color ratio of backscatter, Particle linear depol. ratio, Particle extinction coefficient	- Water vapor profile
SMART	- Spectral upwandard and downward irradiance (300-2200nm)	- Cloud top albedo - Cloud optical thickness - Cloud effective radius - Cloud thermodynamic phase - Liquid and ice water path
specMACS	- Downward-looking hyper-spectral (400-2500nm) line imager	- Cloud mask - Cloud phase - Optical thickness - Effective particle size - Particle size distribution
BAHAMAS	- In-situ observations of T, q, u, v, w (100 Hz) - GPS position	
Thermal imager	- IR camera at 120Hz with four channels between 7.7µm to 12µm	- Cloud mask - Cloud top temperature
Dropsondes	Profiles of RH, T, u, v	

ATR-42

Instrument	Description	Derived products
RASTA cloud radar	- Upward- and downward looking 95 GHz Doppler cloud radar with four antenna configuration for wind-vector retrievals	- 3D wind (upward) - Vertical wind (downward) - Boundary layer depth (upward)
LNG lidar	- Backscatter lidar (upward, downwards or 35 deg pointing) (355nm, 532nm, 1064nm)	- Boundary layer depth (upward) - Vertical velocity in aerosol layer - Optical parameters of aerosol and clouds
BASTA cloud radar	- Doppler radar at 95 GHz looking sideways	- Cloud fraction and cloud optical properties just above cloud base height
ALIAS lider	- Backscatter lidar at 355nm looking sideways	- Cloud fraction (about 10km) and cloud optical properties just above cloud base height
Radiometers	- Three channel downward staring measurements of IR irradiance at 8.7, 10.8 and 12µm - VIS camera (looking sideways)	- SST
Pyrgeometer	- Hemispheric broadband upwelling and downwelling thermal infrared radiative fluxes	
Pyranometer	- Hemispheric broadband upwelling and downwelling solar radiative fluxes	
several	In-situ: - Liquid and total water contents - Droplet size distribution (0.5-6000µm); 2D particle imaging (25-6000µm) - Water isotopes - Water vapor, temperature, pressure, 3D wind, momentum and heat fluxes	

Possible additional planes

Highlights

BAS Twin Otter	In situ aerosol and cloud microphysical properties (e.g. PSD from 25 nm to 1600 µm)
NOAA G-IV	Dropwindsondes system and Tail Doppler Radar
NOAA P3	Lower fuselage C-band research radar – 360 deg. horizontal fan beam, sea surface temperature radiometer and dropwindsonde system

Do you have questions?

How many aircraft-ship overpasses are needed/feasible?
Do you need overpasses for calibration reasons?
Is one aircraft/set of instrumentation more useful for comparison?

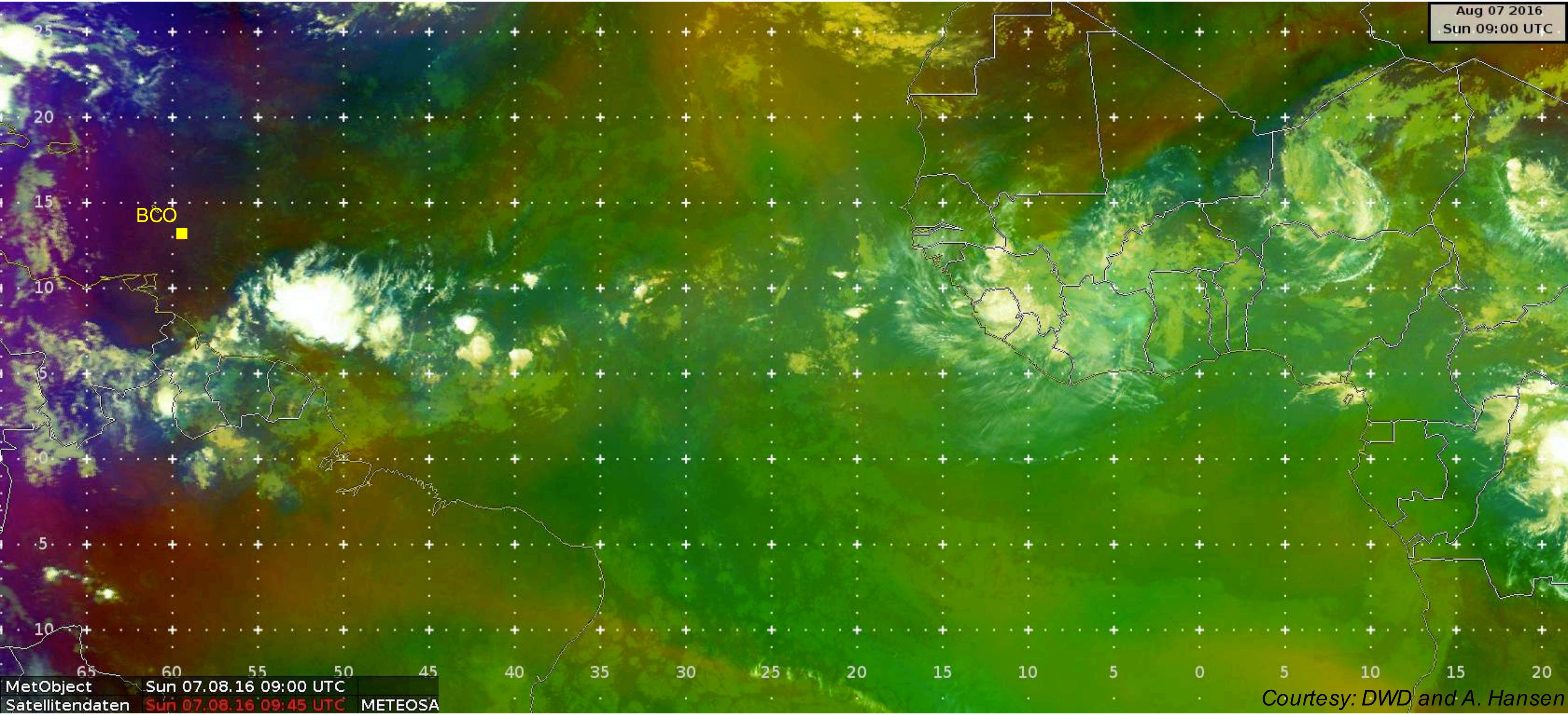
Remote sensing measurements at the Barbados Cloud Observatory (BCO)

Marcus Klingebiel

19 February 2019

Max-Planck-Institut für Meteorologie

BCO - Location



BCO - Location

Shallow cumulus clouds...

- ...have a significant impact on Earth's **radiation budget** and upon the energy and water cycles (Neggers et al. 2007; Long et al. 2013).
- ...form **20% of the total precipitation** in the tropics (Short and Nakamura, 2000).
- ...induced precipitation plays an important role for the **evolution of the boundary layer** (Jensen, 2000).

BCO - Location

Stevens et al. (2016)

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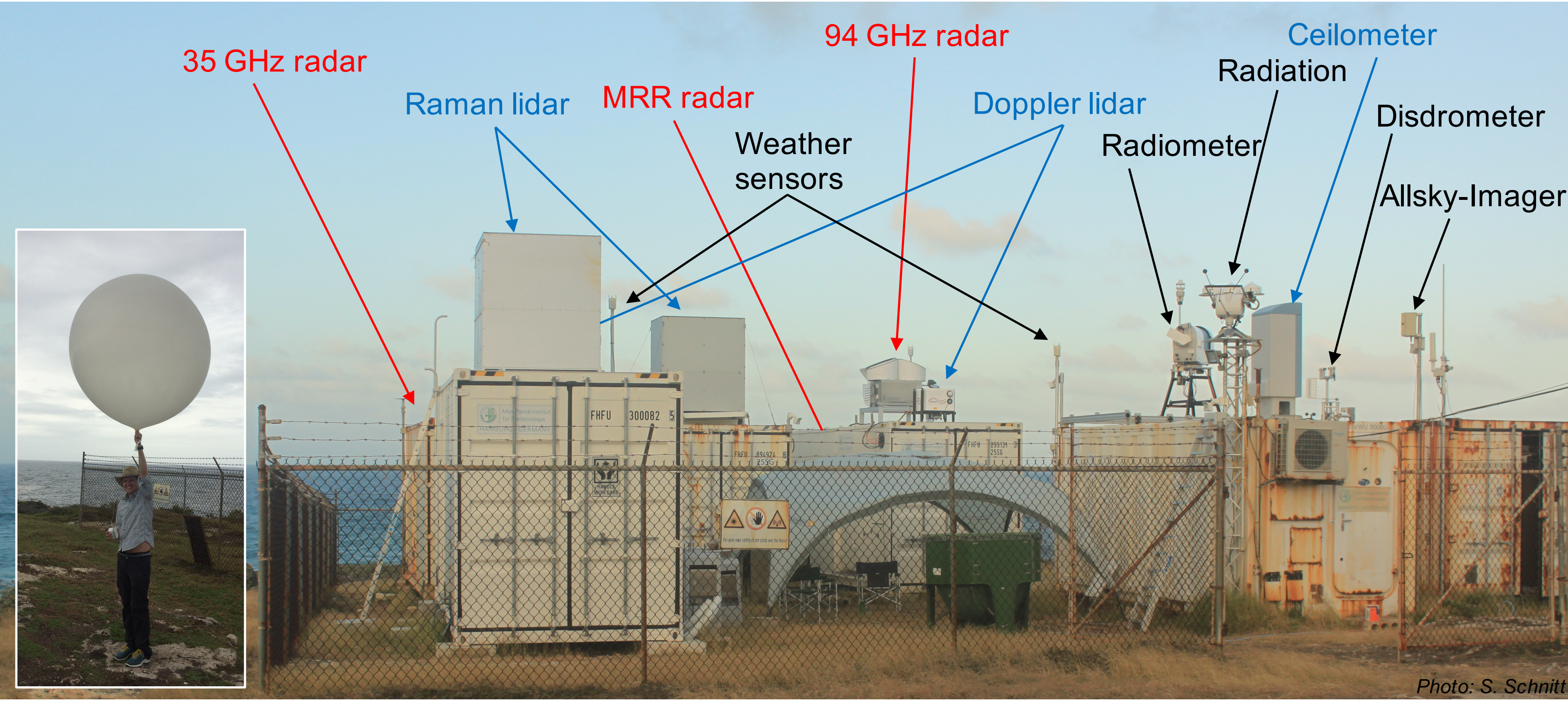
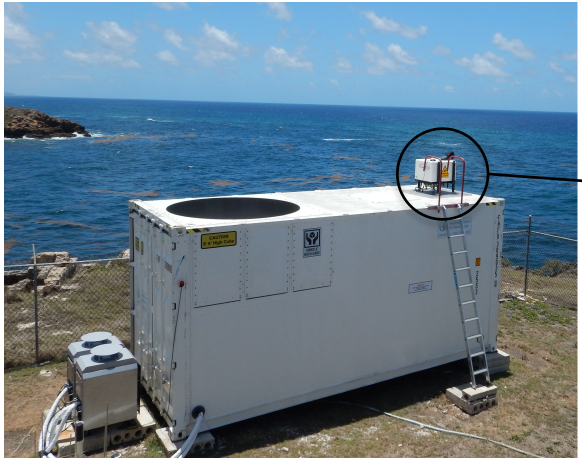
BCO - Instruments



BCO - Instruments

Ka – Band Cloud Doppler radar



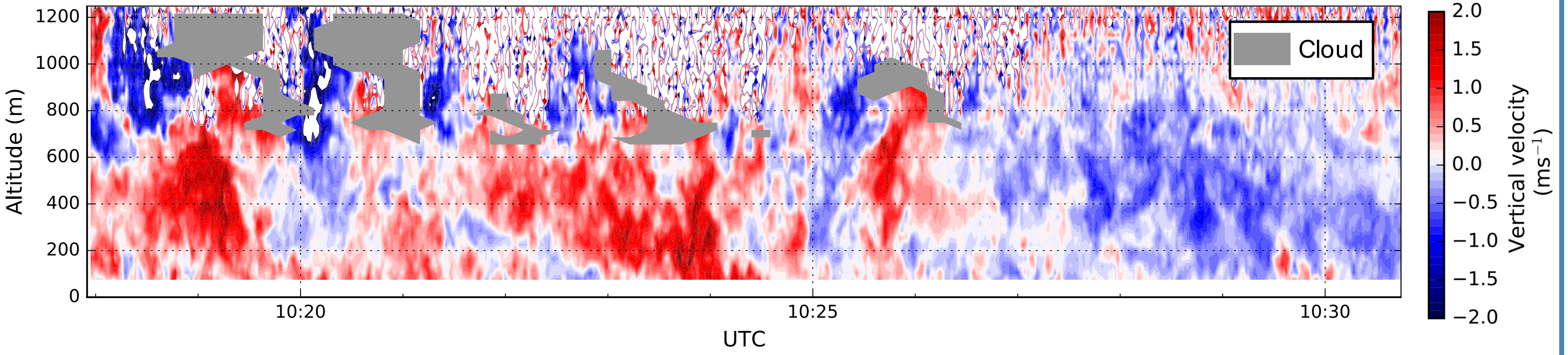
- 35.5 GHz
- temporal resolution of 10 s (2 s since May 2018)
- antenna diameter of 2 m
- vertical range up to 25 km
- sensitivity of -57 dBZ at 5 km

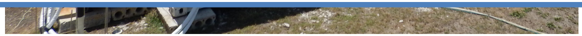
Doppler lidar

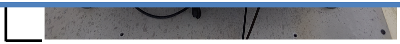
- 1500 nm
- temporal resolution of 1.3 s
- vertical velocities up to 20 m s^{-1}
- in an altitude between 50 m and ca. 1 km

BCO - Instruments

Combining the radar and Doppler lidar instrument







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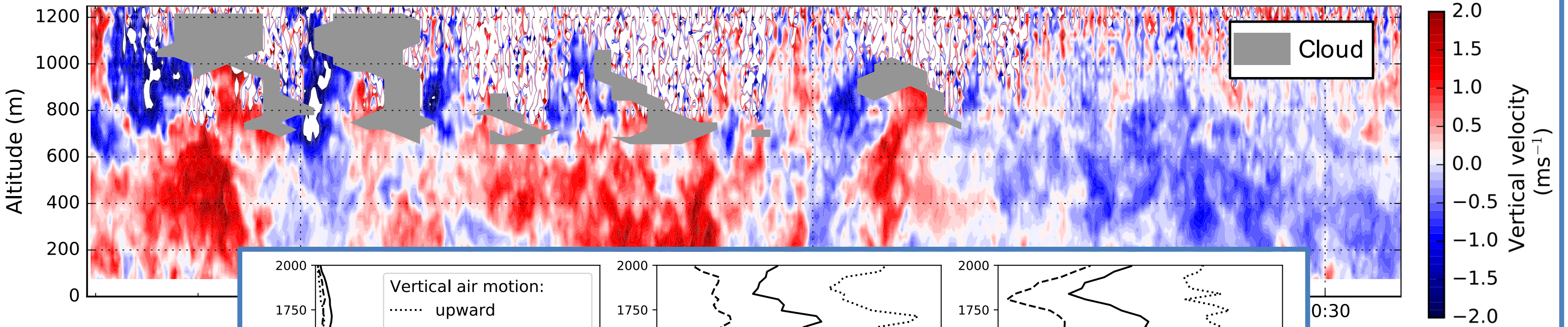

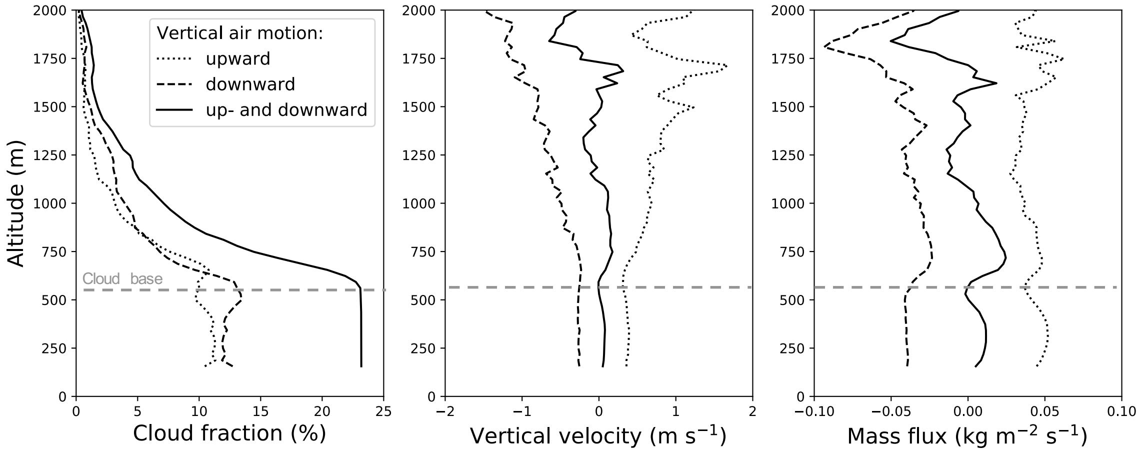

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- temporal re… …tion of 1.3 s
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- vertical ran… …tween 50 m and
- sensitivity …

BCO - Instruments

Ka – Band Cloud Doppler radar

- 35.5 GHz
- temporal resolution of 10 s (2 s since May 2018)
- antenna diameter of 2 m
- vertical range up to 25 km
- sensitivity of -57 dBZ at 5 km

S. Schnitt is combining **dual-frequency radar** and **microwave radiometer** for **water vapor profiling** in the cloudy atmosphere.

W – Band Cloud Doppler radar

Photo: Radiometer-Physics

- 94 GHz
- antenna diameter of 2 m
- vertical range up to 16 km
- sensitivity of -47 dBZ at 4 km

Take home messages...

The **Barbados Cloud Observatory** is located in the tropical trade wind region and measures since 2010 cloud and aerosol properties, solar radiation, vertical air motion, standard meteorology (T, p, u, etc.) …

Website: barbados.mpimet.mpg.de

The instruments at the **Barbados Cloud Observatory** are similar to the payload of the **HALO research aircraft** (35 GHz radar, lidar, Radiometer, radiosondes, solar radiation instruments).

Thank you!

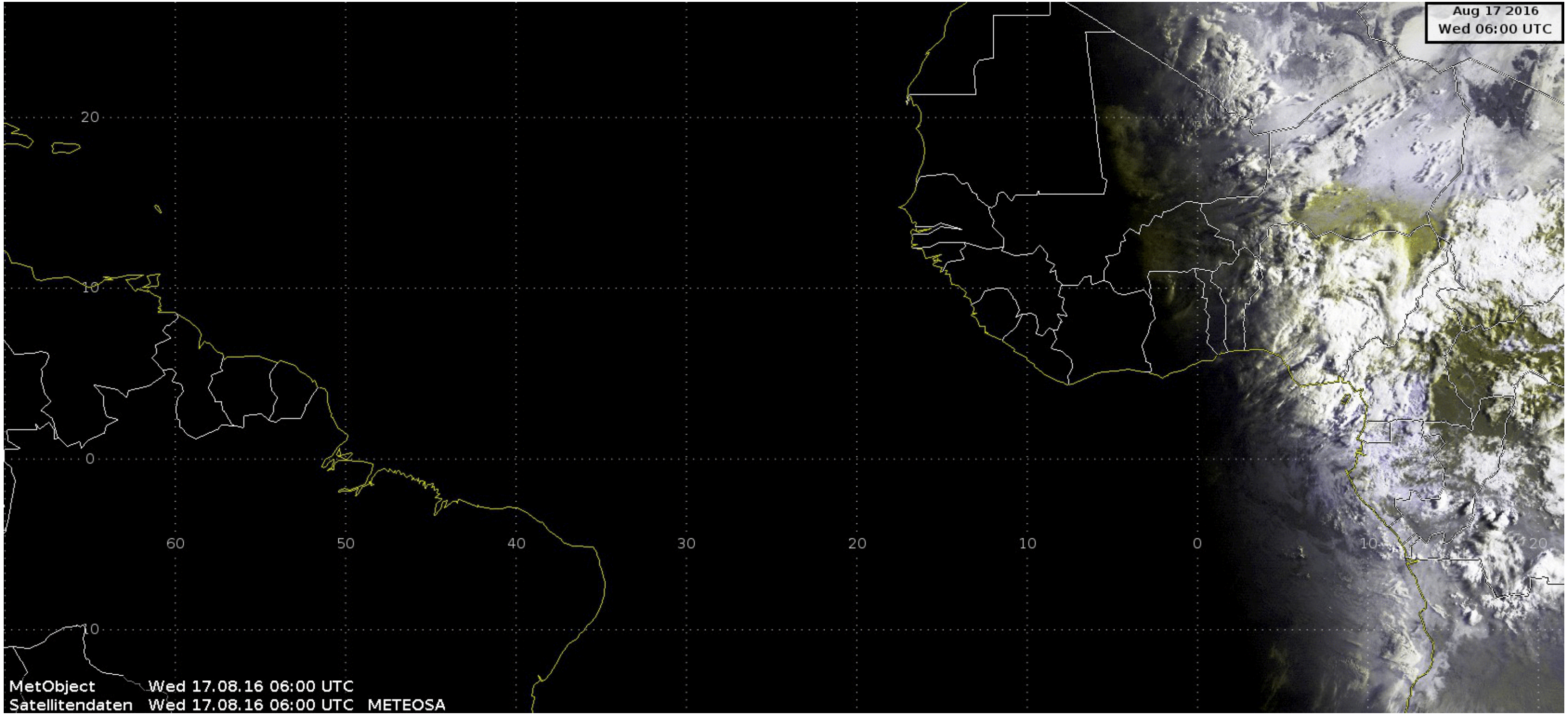
EUREC4A++ - Satellite Data

EUREC4A++ Ship Workshop - Hamburg, 19. - 20.02.2019

Akio Hansen

Met. Institute, University Hamburg

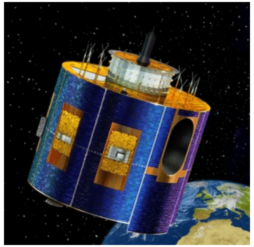
Meteosat-10 Satellite – Real Color (17/08/16)



http://37.120.170.199/narval/

Meteosat-10 Satellite Images – Data availability

- Geostationary Meteosat 10 Images processed with DWD NinJo
- Reprocessed from 05/08/16 to 19/09/16 for consistency

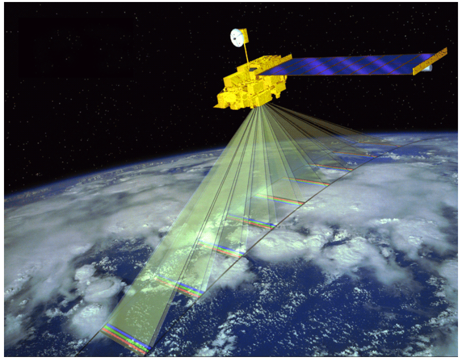


Infrared 1.6 µm	VIS 0.6 µm	Airmass
Infrared 3.9 µm thermal	VIS 0.8 µm	Cloudtop
Infrared 8.7 µm	Water Vapor 6.2 µm	Ice Clouds
Infrared 9.7 µm	Water Vapor 7.3 µm	Night Micro Physics
Infrared 10.8 µm	HRV	Real Color
Infrared 12.0 µm	24hr Dust product	Severe Convection
Infrared 13.4 µm		

ftp://ftp-projects.zmaw.de/narval/NARVAL2/MSG_Pictures/

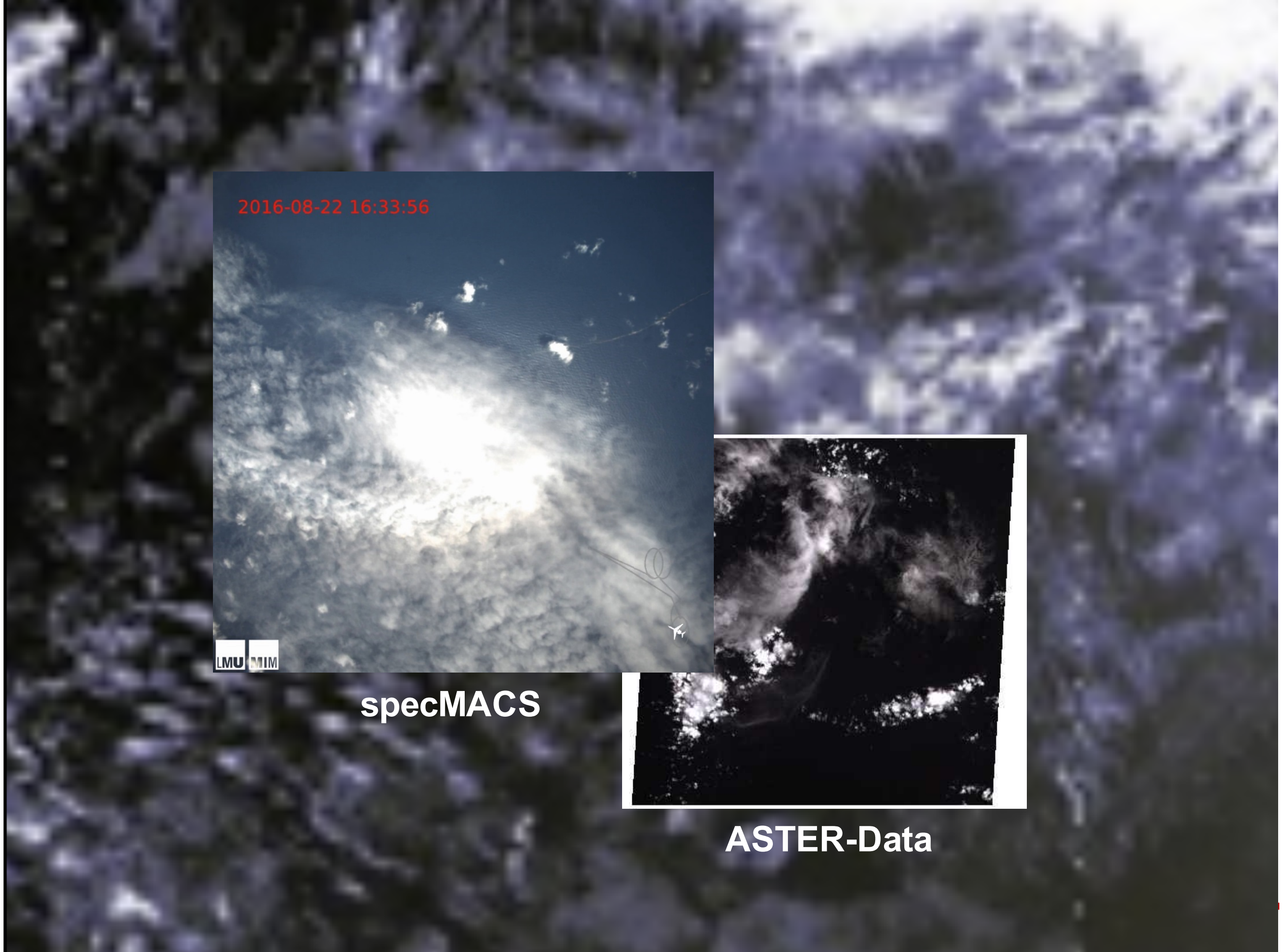
ASTER Satellite Data

- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on board of the TERRA satellite
- **Data is only available on request! Proposal required.**

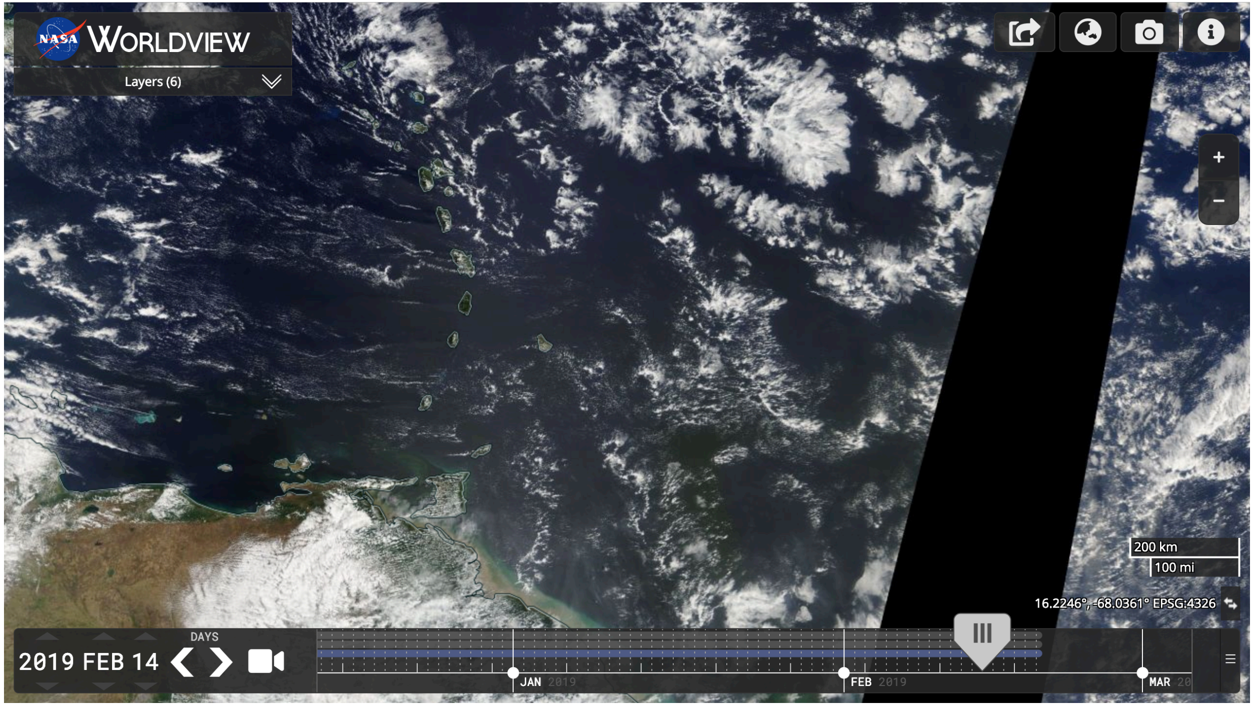


Band	No. of Ch.	Spatial Res.
Visible Near Infrared (VNIR)	3 NADIR 1 Backward	15 m
Short-Wave Infrared (SWIR)	6 NADIR	30 m
Long-Wave/Thermal Infrared (TIR)	5 NADIR	90 m

https://asterweb.jpl.nasa.gov


2016-08-22 16:33:56
LMU MIM
specMACS
ASTER-Data

MODIS Satellite Data (AQUA / TERRA)

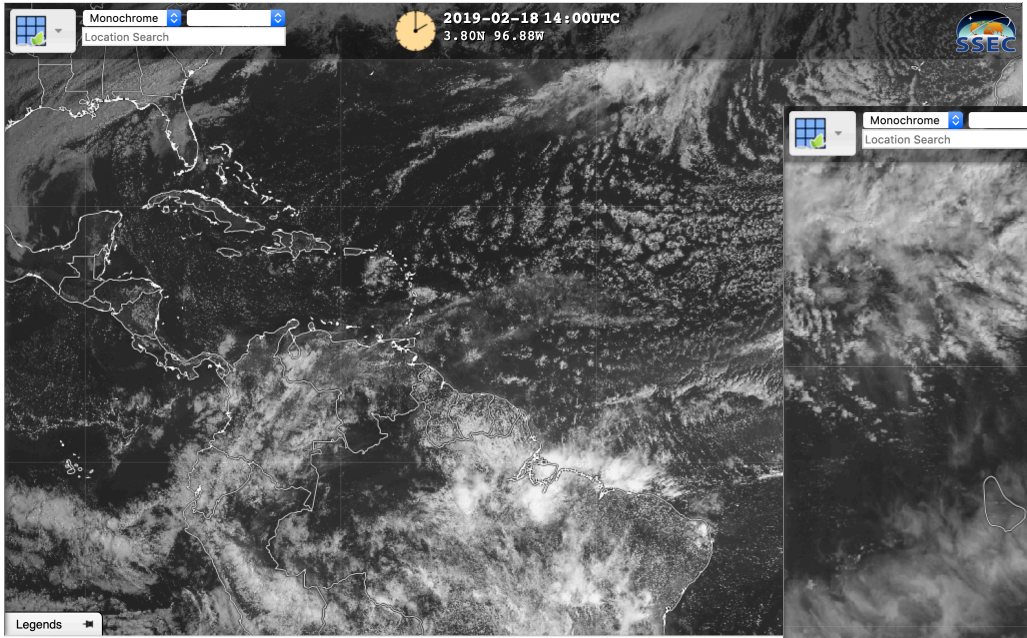


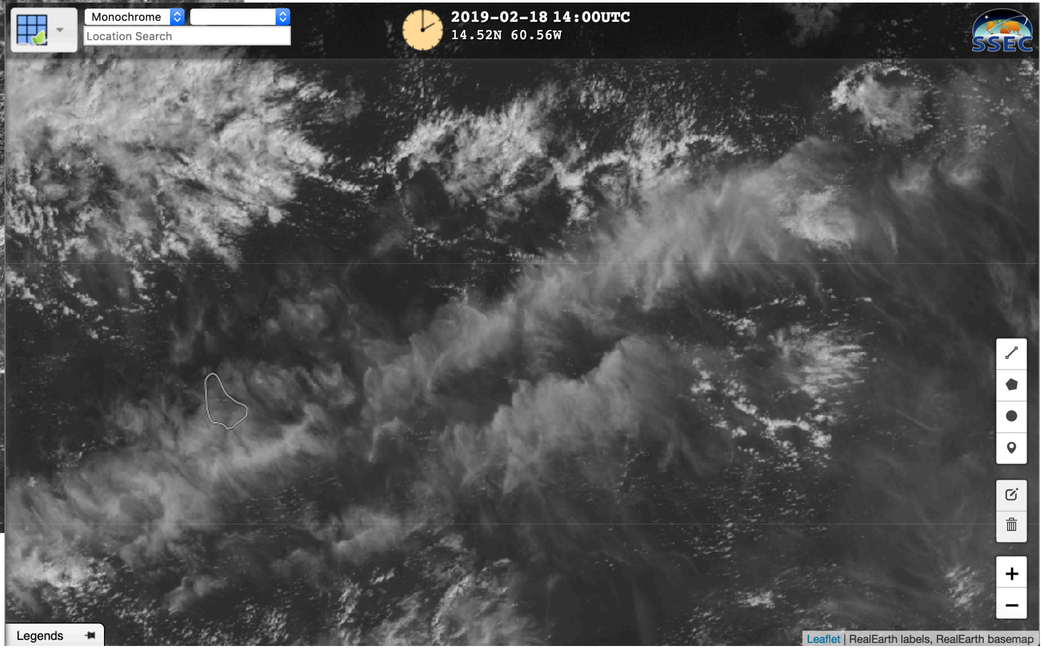
- Moderate Resolution Imaging Spectrometer
- Nominal NADIR resolution: 250 m
- Two datasets per day

https://worldview.earthdata.nasa.gov

GOES-R 16 Satellite data

- Geostationary satellite: up to 500 m spatial and 15 minutes





http://re.ssec.wisc.edu

Cloudsat / A-Train Overpass Times

Cloudsat closest daytime overpass time:

2020/01/20: 17:44 UTC (180 km)
2020/01/21: 18:18 UTC (1088 km)
2020/01/22: 17:15 UTC (572 km)
2020/01/23: 17:52 UTC (434 km)
2020/01/24: 16:52 UTC (1226 km)
2020/01/25: 17:29 UTC (221 km)
2020/01/26: 18:06 UTC (785 km)
2020/01/27: 17:04 UTC (875 km)
2020/01/28: 17:41 UTC (131 km)
2020/01/29: 18:18 UTC (1137 km)
2020/01/30: 17:18 UTC (523 km)
2020/01/31: 17:55 UTC (483 km)
2020/02/01: 16:53 UTC (1177 km)
2020/02/02: 17:30 UTC (172 km)
2020/02/03: 18:07 UTC (834 km)
2020/02/04: 17:07 UTC (826 km)
2020/02/05: 17:44 UTC (180 km)

Cloudsat closest nighttime overpass time:

2020/01/20: 05:17 UTC (937 km)
2020/01/21: 05:51 UTC (30 km)
2020/01/22: 06:29 UTC (976 km)
2020/01/23: 05:28 UTC (684 km)
2020/01/24: 06:04 UTC (322 km)
2020/01/25: 06:42 UTC (1327 km)
2020/01/26: 05:41 UTC (332 km)
2020/01/27: 06:17 UTC (673 km)
2020/01/28: 05:15 UTC (986 km)
2020/01/29: 05:54 UTC (19 km)
2020/01/30: 06:30 UTC (1025 km)
2020/01/31: 05:29 UTC (635 km)
2020/02/01: 06:06 UTC (371 km)
2020/02/02: 05:04 UTC (1289 km)
2020/02/03: 05:42 UTC (283 km)
2020/02/04: 06:19 UTC (722 km)
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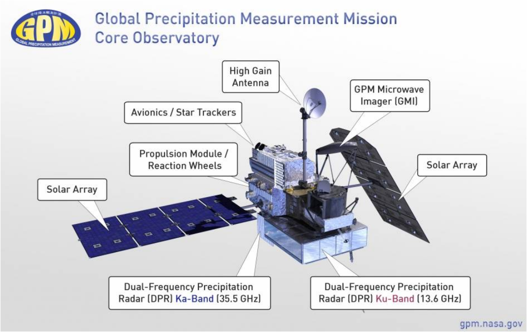
BCO: Longitude: -59.535639,
Latitude: 13.1901325

http://www.icare.univ-lille1.fr/predictor/

GPM Core Satellite

- Global Precipitation Measurement (GPM)
- 13 channels from 10 GHz to 183 GHz, swath of 904 km
- Sensors:
  - Dual-frequency Precipitation Radar (DPR)
  - GPM Microwave Image (GMI)



- IMERGE product: combines and intercalibrates all available passive microwave precip. estimates with GPM core observatory and rain gauges

Time resolution	30 minutes
Spatial resolution	0.1° ~ 11 km

https://pmm.nasa.gov/gpm

ICDC – Satellite dataset offers

- Two buoys time-series of last 3-5 years
  - Significant wave height and period
  - Windspeed and –direction
- 10 years satellite climatology of significant wave height (1x1°)
- Climatology of sea level anomalies (SLA)

- MODIS data on 1x1° grid
  - Total cloud cover, liquid phase, ice phase, undetermined phase
  - Cloud water (liquid, ice, undetermined phase)
  - Number of CCNs
  - Effective particle radius, Optical depth
  - Aerosol Optical depth datasets

http://icdc.cen.uni-hamburg.de/

Thank you for your attention!

Questions?! Data Archiving? Data distribution? Required products?