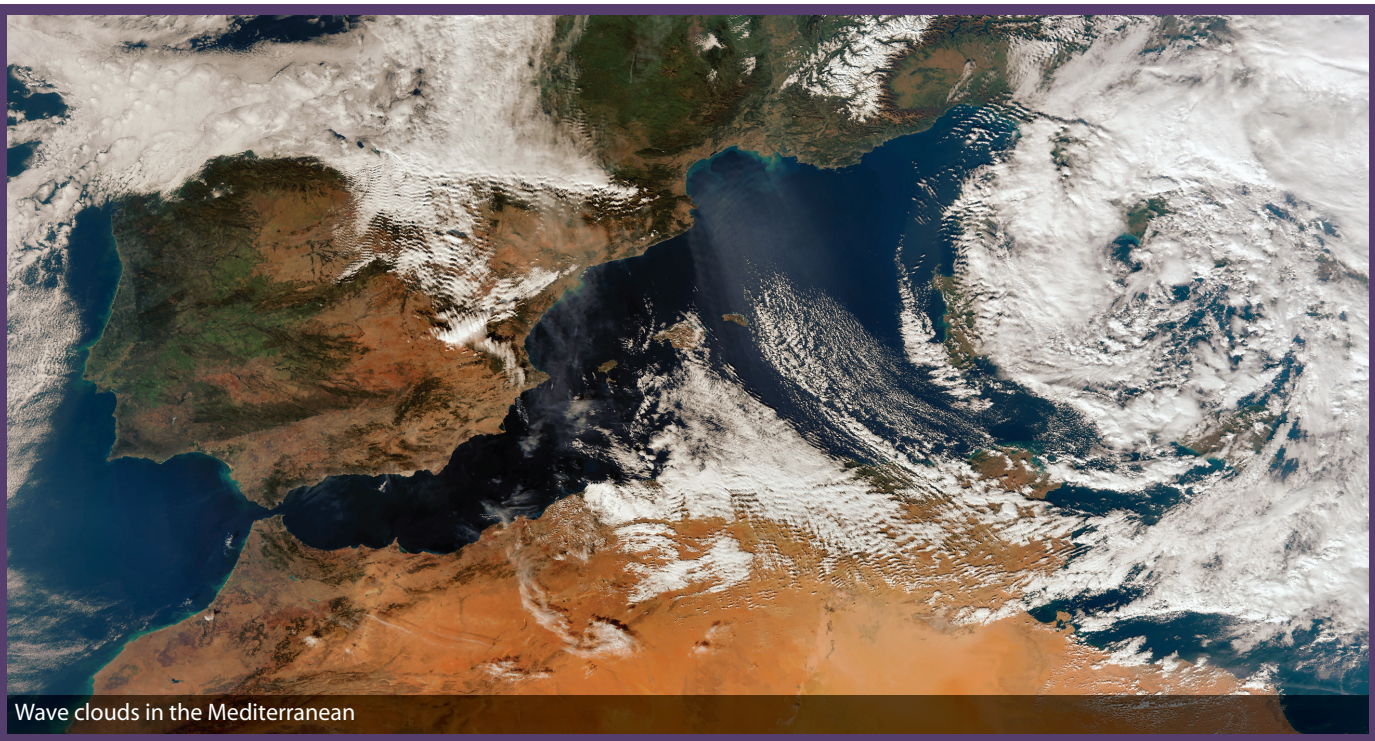
Dartcom

WEATHER SATELLITE AND REMOTE SENSING GROUND STATIONS

X-Band EOS System

Affordable, high-performance solution for ingesting X-Band EOS data from Terra/Aqua (MODIS), Suomi NPP, JPSS, FengYun-3 (FY-3) and Metop-SG* satellites



Wave clouds in the Mediterranean

2015 Bárðarbunga volcanic eruption, Iceland

X-Band Earth Observation Satellite (EOS) data is essential for accurate monitoring of global weather and climate patterns. It is also invaluable for remote sensing work, such as monitoring ocean currents, detecting forest fires and mapping land use.

However, X-Band EOS reception systems have always tended to be very expensive to purchase and maintain. They also normally require specialised installation procedures and building works.

The Dartcom X-Band EOS System changes that, bringing X-Band within reach of universities, research institutions and other organisations with limited budgets and restricted installation sites.

It was developed from the outset as a lower cost X-Band system which still offers performance and features competitive with much more expensive products. Dartcom has achieved this with a smaller antenna, state-of-the-art RF components, tight tolerances and advanced software. Land-based and marine antennas are available.

* Hardware is Metop-SG ready but a future software update will be needed to receive it.

Overview

The Dartcom X-Band EOS System comprises the following:

Outdoor equipment

- 2m diameter radome with hydrophobic coating to minimise signal loss caused by standing water during rainfall.
- 1.5m prime focus aluminium parabolic dish antenna.
- Rotator/pedestal and controller (land-based and marine options).
- Scalar feed horn and low-noise block downconverter (LNB).
- Rugged, weatherproof GPS/GNSS antenna.
- Optional radome environmental control unit for hot climates.
- Optional radome heater for very cold climates.

All the outdoor equipment is housed within the radome.

Indoor equipment

- Modular system interface rack.
- State-of-the-art demodulator.
- Gigabit network switch.
- Uninterruptible power supply (UPS).
- Optional temperature sensor unit for temperature monitoring.
- Ingest PC.
- Processing and visualisation PC.

All units can be rack-mountable and supplied in an optional floor-standing cabinet for a complete rack-mounted system.

Features

- Automatic data reception from Terra, Aqua, Suomi NPP, JPSS and FengYun-3 (FY-3) X-Band Earth observation satellites, with Metop-SG capability requiring only a future software update.
- Combined X/L-Band option allowing reception from X-Band and L-Band satellites using the same antenna system.
- Cost-effective upgrade path for existing L-Band (HRPT/AHRPT) systems to next generation X-Band Earth observation satellites.
- Complete end-to-end solution with automatic data processing to level 0, 1 and 2 *(currently level 0 and 1 only for FY-3)*.
- Affordable to meet the limited budgets available for X-Band systems in universities and research institutions.
- Simple installation with minimal civil engineering works.
- 1.5m antenna system enclosed in a radome to allow normal operation at wind speeds up to 185km/h (100kt or 115mph).
- State-of-the-art RF components, allowing good data reception from 15° elevation. In practice good quality data can be received from Terra, Suomi NPP and JPSS at 7°, and Aqua and FY-3 at 5°.
- Automatic daily prediction data updates from the internet.
- Optional temperature monitoring with automatic tracking lockout.
- All external components designed and treated to survive tropical and marine environments, with at least IP65 protection rating.
- Modular construction for easy maintenance and future upgrades.
- Comprehensive hardware and software diagnostics at all levels.

Dartcom X-Band EOS System at the University of Valladolid, Spain, with antenna (circled) installed on a lift shaft

Dartcom X-Band EOS and L-Band Systems at the National Institute for Space Research (INPE) in Cuiabá and Cachoeira Paulista, Brazil

Dartcom X/L-Band EOS System at Chulabhorn Satellite Receiving Station, Kasetsart University in Bangkok, Thailand

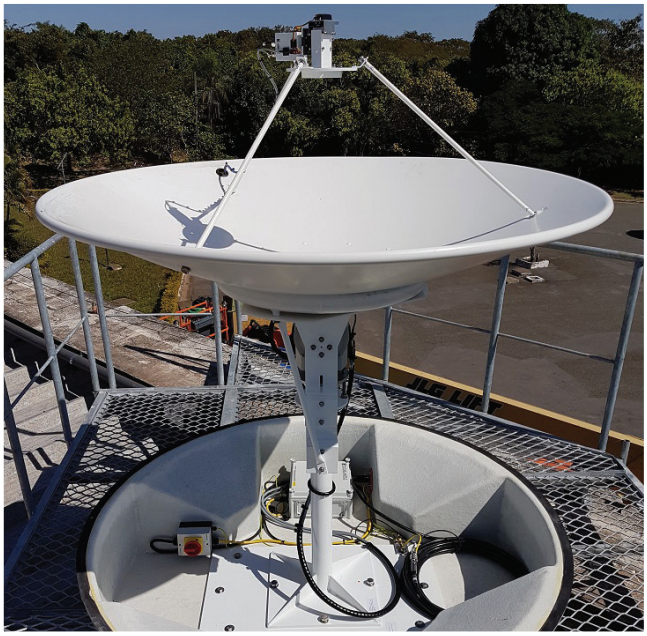
Dartcom Marine X/L-Band EOS System on British Antarctic Survey research ship *RRS Sir David Attenborough* (antenna circled)

Antenna options

The antenna can be supplied in land-based or marine variants. Both use essentially the same radome, dish and RF components.

Land-based antenna

- High-speed dual-axis antenna rotator (elevation over azimuth).
- Dartcom XPA rotator controller with PID function and closed-loop feedback for excellent pointing accuracy and smooth tracking.
- Automatically controlled by the ingest PC via RS-485 serial.



Radome removed from land-based antenna to show 1.5m parabolic dish antenna, scalar feed horn and LNB

Marine antenna

- Active-stabilised pedestal to compensate for pitch, roll and yaw.
- X-Y head with continuous movement to eliminate cable wrap.
- Automatically controlled by the ingest PC via TCP/IP.
- Waveguide bandpass filter fitted between the scalar feed horn and LNB to prevent interference and damage from X-Band radar.

Active-stabilised marine antenna

Land-based antenna rotator specifications

Control	Dual-axis PID controller with closed-loop feedback
Movement limits	0–360˚ azimuth
	0–180˚ elevation
Speed	48˚/sec azimuth
	10˚/sec elevation
Mechanical tolerance	±0.15˚
Tracking accuracy	±0.1˚
Weight	186kg (including radome)
Operating temperature	–20˚C to +60˚C unheated
	–40˚C to +60˚C with optional radome heater
Survival temperature	–35˚C to +75˚C

Marine antenna pedestal specifications

Control	X-Y head with active stabilisation in pitch, roll and yaw
Movement limits	None (continuous movement)
Vessel motion:	
Roll	±30˚ @ 8 sec
Pitch	±15˚ @ 8 sec
Yaw	±80˚ @ 50 sec
Surge	±0.2g
Sway	±0.2g
Heave	±0.2g
Turning rate	10˚/sec
Weight	180kg (including radome)
Power requirements	110/220V AC (±5%)
	50/60Hz (+0, –3%)
	660W
Wild heat	660W
Operating temperature	–10˚C to +70˚C unheated
	–40˚C to +70˚C with optional radome heater
Survival temperature	–35˚C to +75˚C
Humidity	95% @ 40˚C
EMI/RFI	MIL-STD-461
Vibration	Designed to meet MIL-STD-167-1
Shock	Designed to meet MIL-STD-901

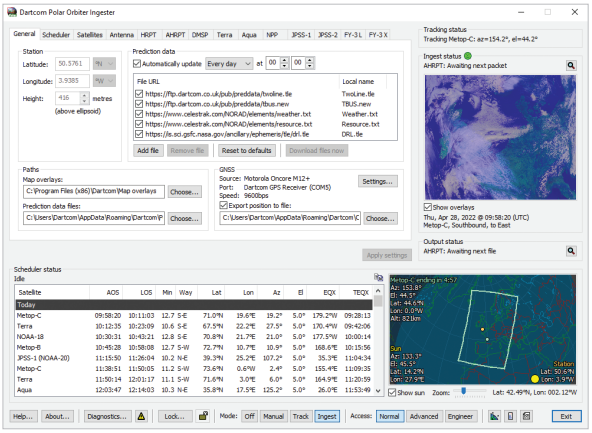
Radar filter specifications

Passband	7750–8400MHz
Insertion loss at band edges	0.25dB maximum
VSWR	1.2:1 maximum
Rejection from 9300–9500MHz	100dB minimum
Operating temperature	–10˚C to +50˚C

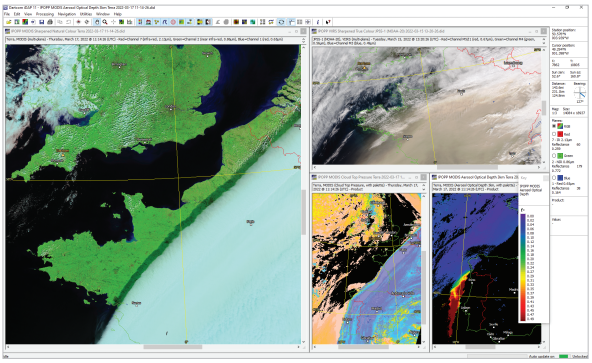
Indoor equipment

- Modular system interface rack containing software controlled RF module, GPS/GNSS receiver, USB hub and serial communications module, and switch mode power supply.
- State-of-the-art demodulator with field-upgradeable firmware.
- Gigabit network switch.
- Uninterruptible power supply (UPS).
- Optional temperature sensor unit for temperature monitoring.
- Ingest PC running Polar Orbiter Ingester software on Windows.
- Processing and visualisation PC running NASA RT-STPS, Simulcast and IPOPP software, and CMA FY3L0pp/FY3L1pp software, on Linux Hyper-V virtual machines hosted on Windows, plus iDAP/MacroPro software running natively on Windows.
- Optional flip-up KVM console drawer.
- Optional HDBaseT remote console.
- Desktop cabinet as standard.
- Optional floor-standing cabinet for a fully self-contained system.

Floor-standing equipment cabinet with rack-mount PCs and KVM console



Dartcom Polar Orbiter Ingester software



Dartcom iDAP/MacroPro display and processing software

Desktop processing and visualisation PC with multiple displays

Technical summary

The antenna system automatically tracks satellites and receives direct broadcast RF transmissions which are focused into the scalar feed horn by the parabolic dish and then fed to the low-noise block downconverter. This amplifies the signal and downconverts it to a lower frequency to minimise cable loss.

The signal is then fed to the RF module in the system interface rack, where it is downconverted to a common frequency (720MHz) and fed to the demodulator.

The demodulator converts the RF signal back to a binary data stream which is then Viterbi decoded, byte-aligned and streamed via a TCP socket to the Polar Orbiter Ingester software running on the ingest PC. This detects the attached synchronisation markers (ASMs) in the data stream and extracts the CCSDS frames (VCDUs) which are then derandomised and Reed-Solomon decoded.

In the case of Terra, Aqua, Suomi NPP and JPSS, the decoded VCDUs are automatically streamed via a TCP socket to the RT-STPS software running on the processing and visualisation PC, which processes them and displays a preview in the Simulcast software. The IPOPP software automatically processes the resulting data sets into level 0, 1 and 2 data and products.

FengYun-3 data is assembled into a file which is automatically transferred via a LAN connection to the FY3L0pp and FY3L1pp software running on the processing and visualisation PC. This automatically produces level 0 and 1 data and products.

Land-based and marine antenna specifications

Radome	2m diameter, low-loss composite, hydrophobic coating, white or grey
Antenna type	Prime focus parabolic dish, solid spun aluminium, white powder coated
Dish diameter	1.5m
F/D ratio	0.364
Gain @ 8200MHz	39.3dBiC including 0.4dB radome loss
Feed	Scalar horn
Frequency range	7200–8500MHz
Axial ratio	2dB maximum
Polarisation	RHC/LHC, software controlled
Wind speed	185km/h (100kt) operational
	240km/h (130kt) survival

Demodulator specifications

Input frequency	X-Band 720MHz, L-Band 140MHz
Input dynamic range	–60dBm to 0dBm nominal
Modes	BPSK, QPSK, SQPSK
Implementation loss	<0.2dB typical @ 1:10^6 BER
Symbol rates	0.1Msps to 100Msps
Baseband filter	Root raised cosine (RRC) with variable alpha
Convolution decoding	Viterbi, K=7, rates ½ and ¾, single and dual channel, G1=171, G2=133
Monitoring/control	RJ45 Gigabit Ethernet
	Web interface, OSCP interface
Data outputs	RJ45 Gigabit Ethernet
	Up to 5 simultaneous TCP streams
	SMA clock and data
Supported services	Terra, Aqua, Suomi NPP, JPSS-1/2/3/4, FY-3D/E/F, Metop-SG, NOAA HRPT, Metop AHRPT, DMSP, GOES HRIT, GK-2A LRIT/HRIT
Typical system G/T	19.4dB/K @ 8200MHz

Low-noise block downconverter (LNB) specifications

Input frequency	7750–8400MHz
Noise figure	0.69dB (50K) maximum
	0.6dB (43K) typical
LO frequency	6950MHz
IF output frequency	800MHz–1450MHz
Gain variation within 30MHz	±0.4dB maximum
Gain variation over band	±2dB max
Conversion gain	55dB minimum
Image rejection	40dB minimum
Local oscillator stability	±1.5ppm (–40˚C to +80˚C)
Local oscillator type	Internal Phase Locked Loop (PLL) locked to Temperature Controlled Crystal Oscillator (TCXO)
Phase noise	–90dBc/Hz @ 10kHz typical
	–100dBc/Hz @ 100kHz typical

System interface rack RF module specifications

Input frequency	800–1450MHz
Noise figure	4dB maximum
LO frequency	1520–2170MHz programmable in 100kHz steps
LO stability	±5ppm
Oscillator phase noise	–100dBc/Hz @ 10kHz typical
Output frequency	720MHz
Converted bandwidth	160MHz @ 3dB
IF filter	Dielectric
IF filter bandwidth	140MHz @ 1dB
	160MHz @ 3dB
Conversion gain	20dB typical
Output 1dB compression point	>+19dBm
Monitoring/control	2 × RS-232 serial via USB, software controlled

Combined X/L-Band option

If reception of L-Band NOAA HRPT and Metop AHRPT data is required using the same antenna system, additional RF components can be supplied to allow that.

If L-Band GOES HRIT or GEO-KOMPSAT-2A (GK-2A) LRIT/HRIT reception between polar-orbiter passes is also required, again using the same antenna system, a USB interface and additional software can be supplied.

The X/L-Band feed has 4 dipoles spaced 90˚ apart around the outside of the X-band scalar feed, and a quad hybrid combiner. The L-Band signal is fed to a pre-LNA 3-pole cavity filter followed by a single stage LNA, 4-pole combline bandpass filter and block downconverter.

An additional RF cable feeds the L-Band signal from the antenna system to the second RF input on the system interface rack. The RF module downconverts the signal to a common frequency of 140MHz and feeds that to the demodulator which converts it back to a binary data stream. HRPT and AHRPT data is streamed via a TCP socket to the Polar Orbiter Ingester software running on the ingest PC.

A USB interface and Geostationary Ingester software can be supplied for GOES HRIT or GK-2A LRIT/HRIT reception between polar-orbiter passes. This is fed by the demodulator clock and data outputs and forms a binary data stream which is fed via USB to the Geostationary Ingester software running on the ingest PC.

L-Band pre-LNA filter specifications

Type	3-pole cavity filter
Passband	1680–1710MHz
Passband loss	0.15dB
Bandwidth	–3dB ±86MHz centred on 1705MHz
Stopband loss	300MHz: –80dB
	1200MHz: –35dB
	1570MHz: –10dB
	1866MHz: –10dB
	3000MHz: –50dB

L-Band LNA specifications

Type	Single stage advanced E-PHEMT technology
Noise figure	0.5dB typical
Gain	20dB minimum
IP3	32dBm typical
Temperature	–40 to +85˚C operational

L-Band post-LNA bandpass filter specifications

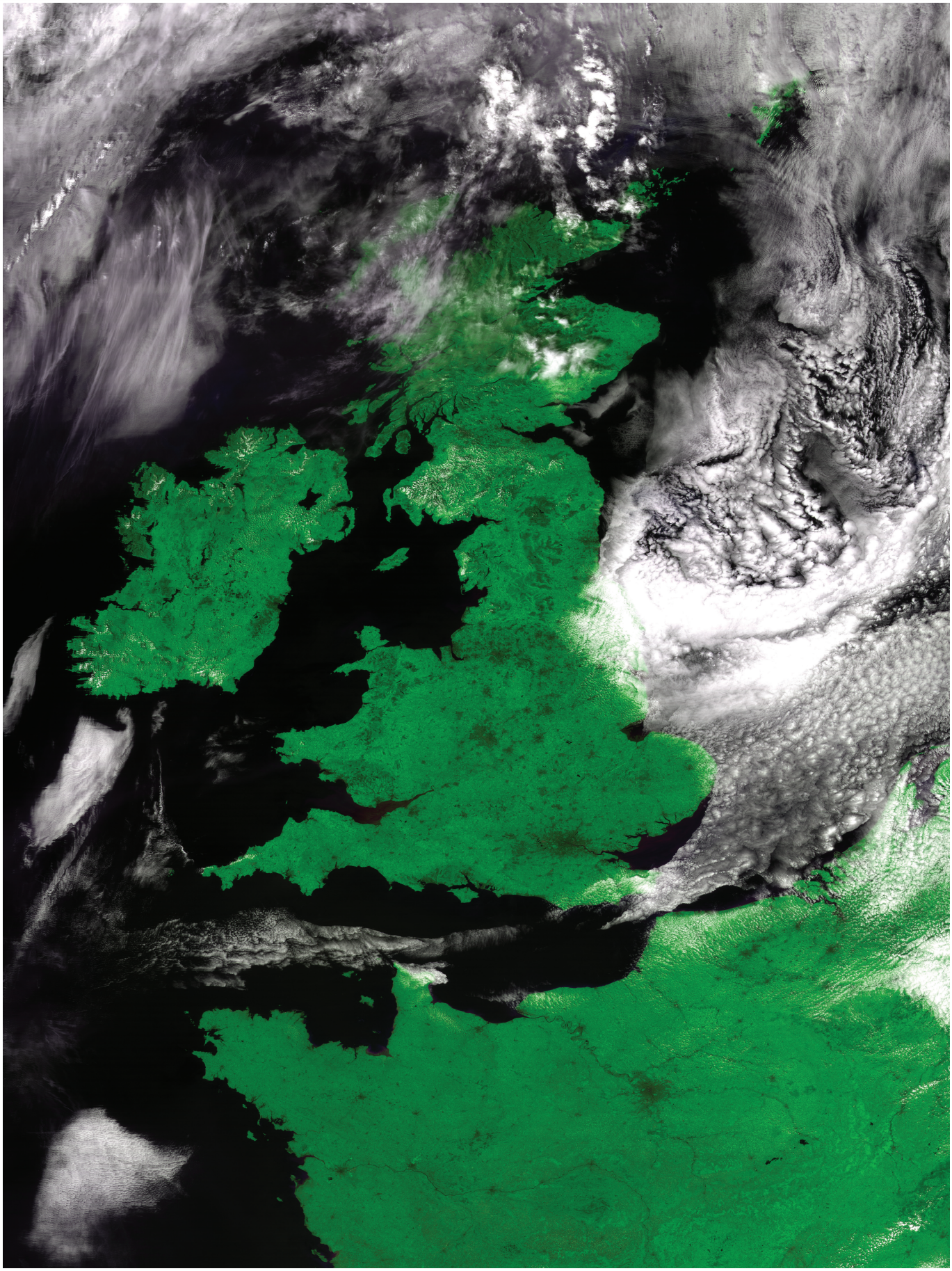
Type	4-pole, Combline
Insertion loss	1.5dB maximum
Bandwidth	1690–1710MHz

L-Band feed specifications

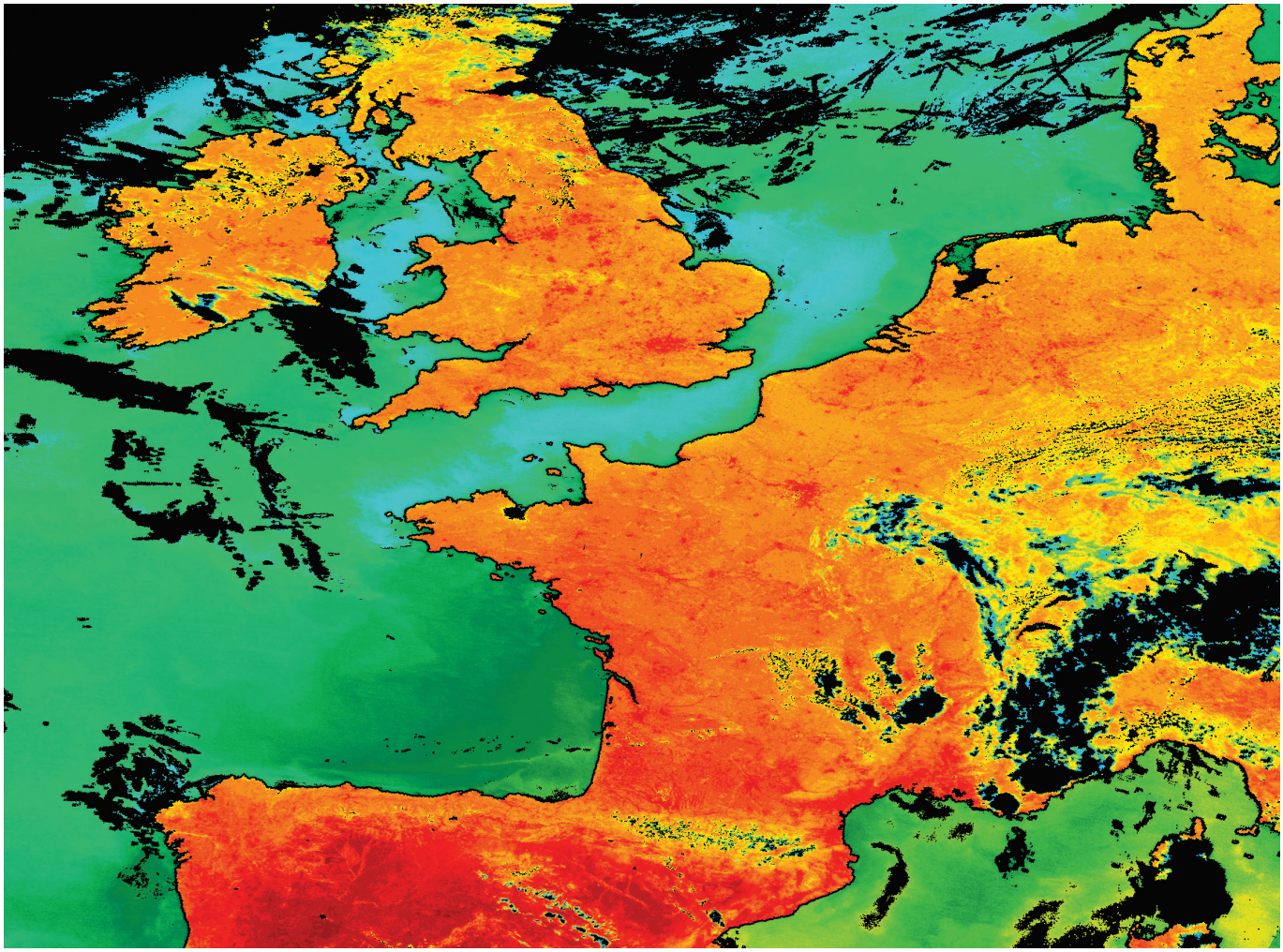
Type	4 dipoles with quad hybrid combiner
Polarisation	RHC

L-Band block downconverter specifications

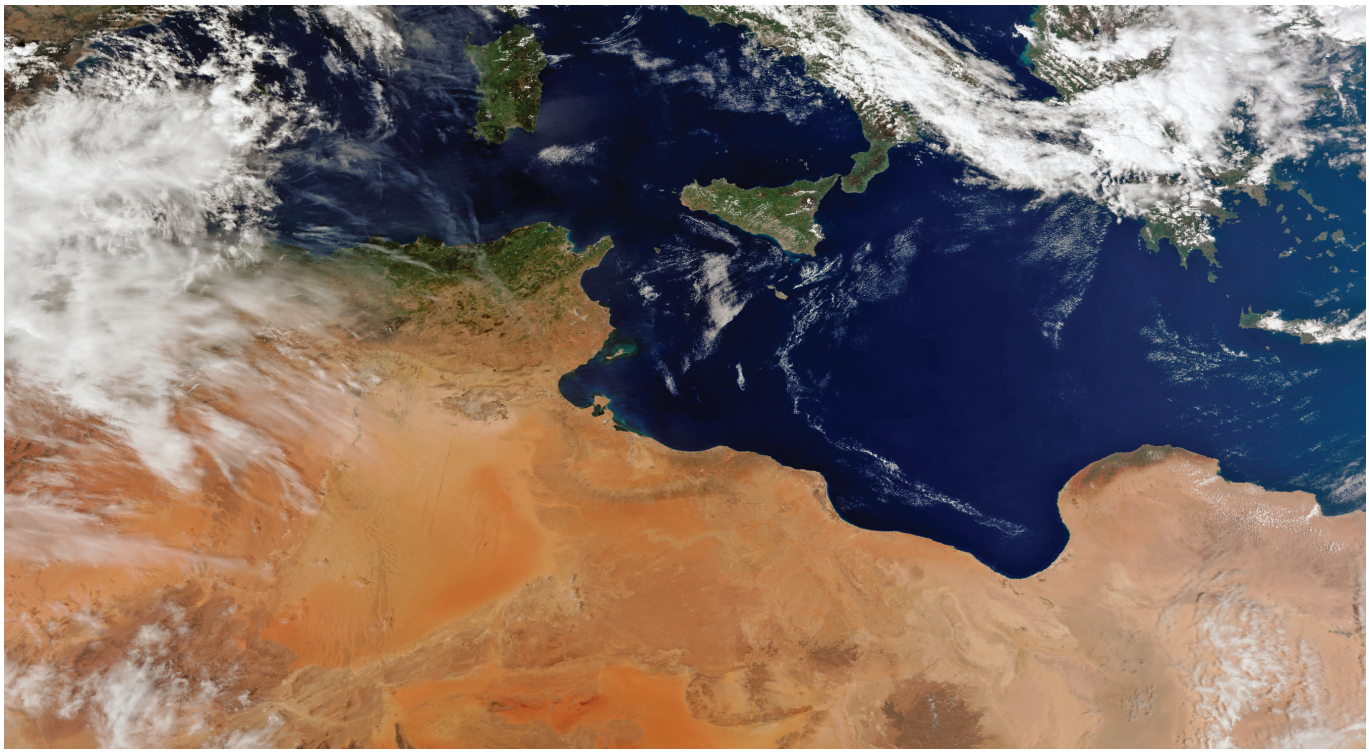
Noise figure	0.75dB typical
Input frequency	1682–1710MHz
LO frequency	1553.500MHz
Output frequency	126.5–154.5MHz
Converted bandwidth	50MHz @ 3dB typical
Conversion gain	>50dB, 55dB typical
Image rejection	>60dB
Input/output impedance	50Ω
Output 1dB comp. point	>+14dBm
LO stability	±2.5ppm (–30 to +60˚C)
LO type	Internal PLL locked to TCXO
Phase noise	–103dBc/Hz @ 10Hz typical
	–130dBc @ 100kHz typical
Input voltage	10–15V DC @ 350mA typical powered via IF output cable
Temperature	–40 to +60˚C operational
Humidity	100% operational



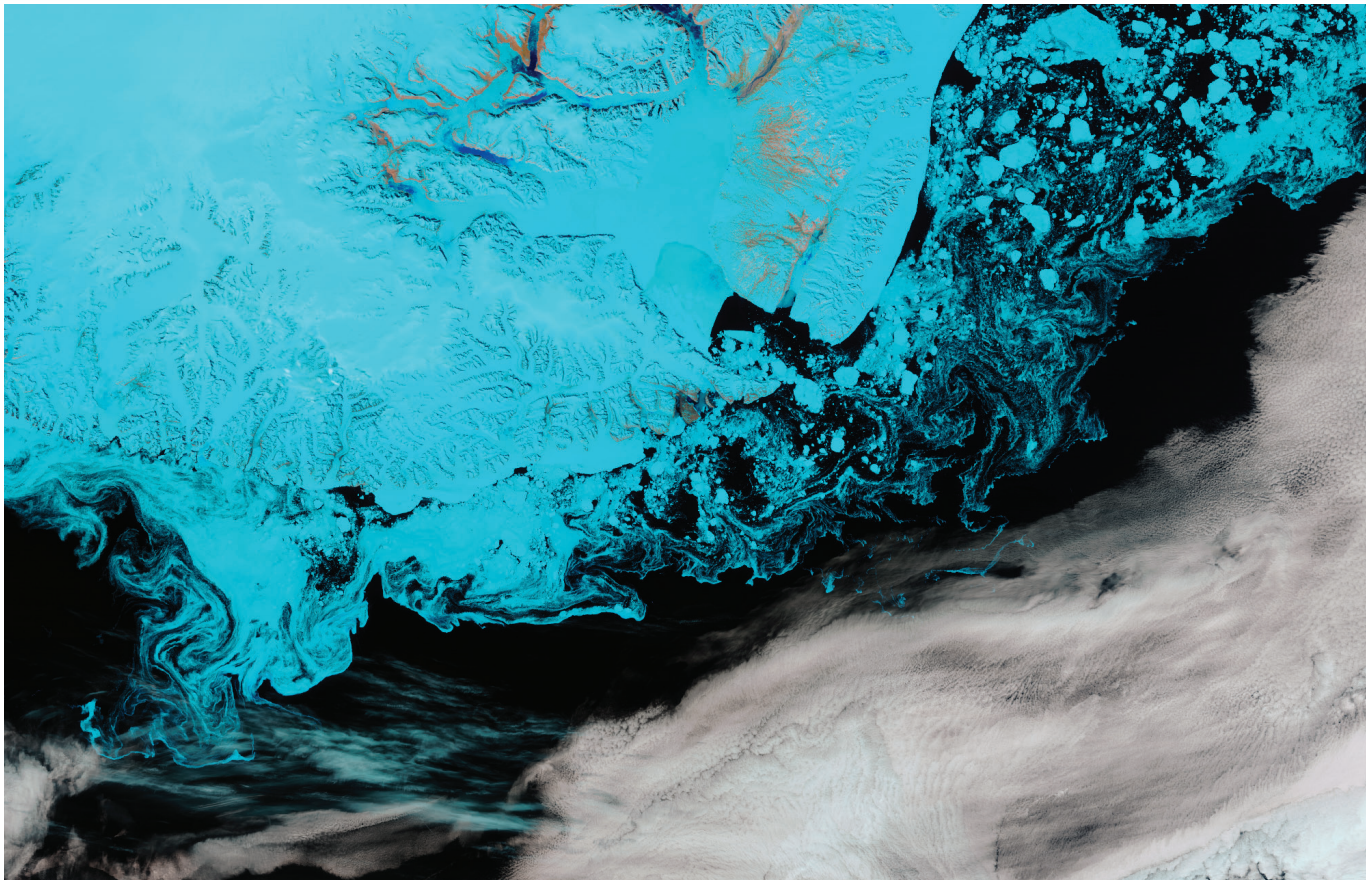
FengYun-3B MERSI 250m resolution false colour composite image showing the UK, Ireland and northern Europe



Terra MODIS Land Surface Temperature (LST) and Sea Surface Temperature (SST) products reprojected and combined

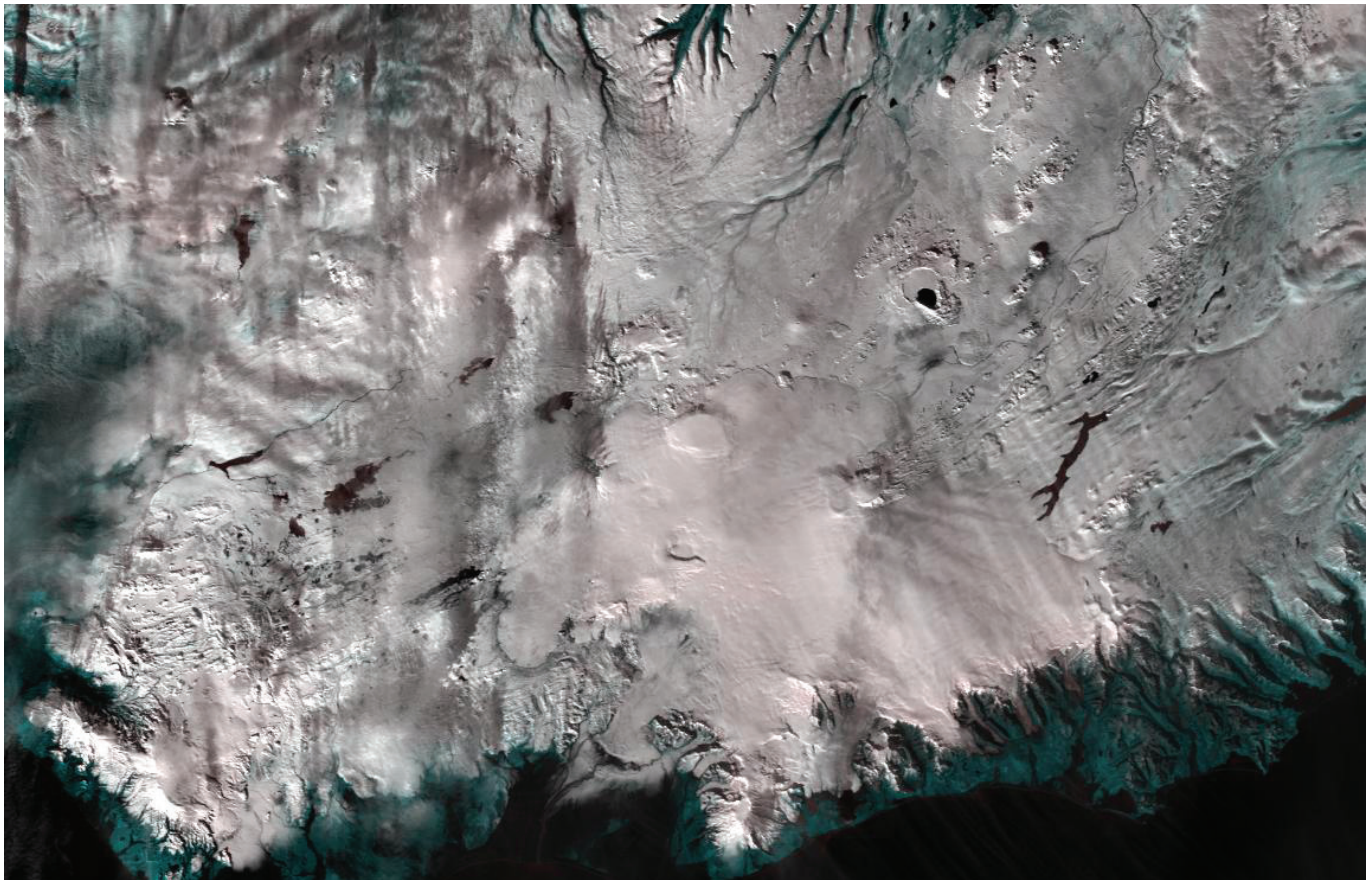


Suomi NPP VIIRS 750m resolution true colour image showing northern Africa and the Mediterranean Sea

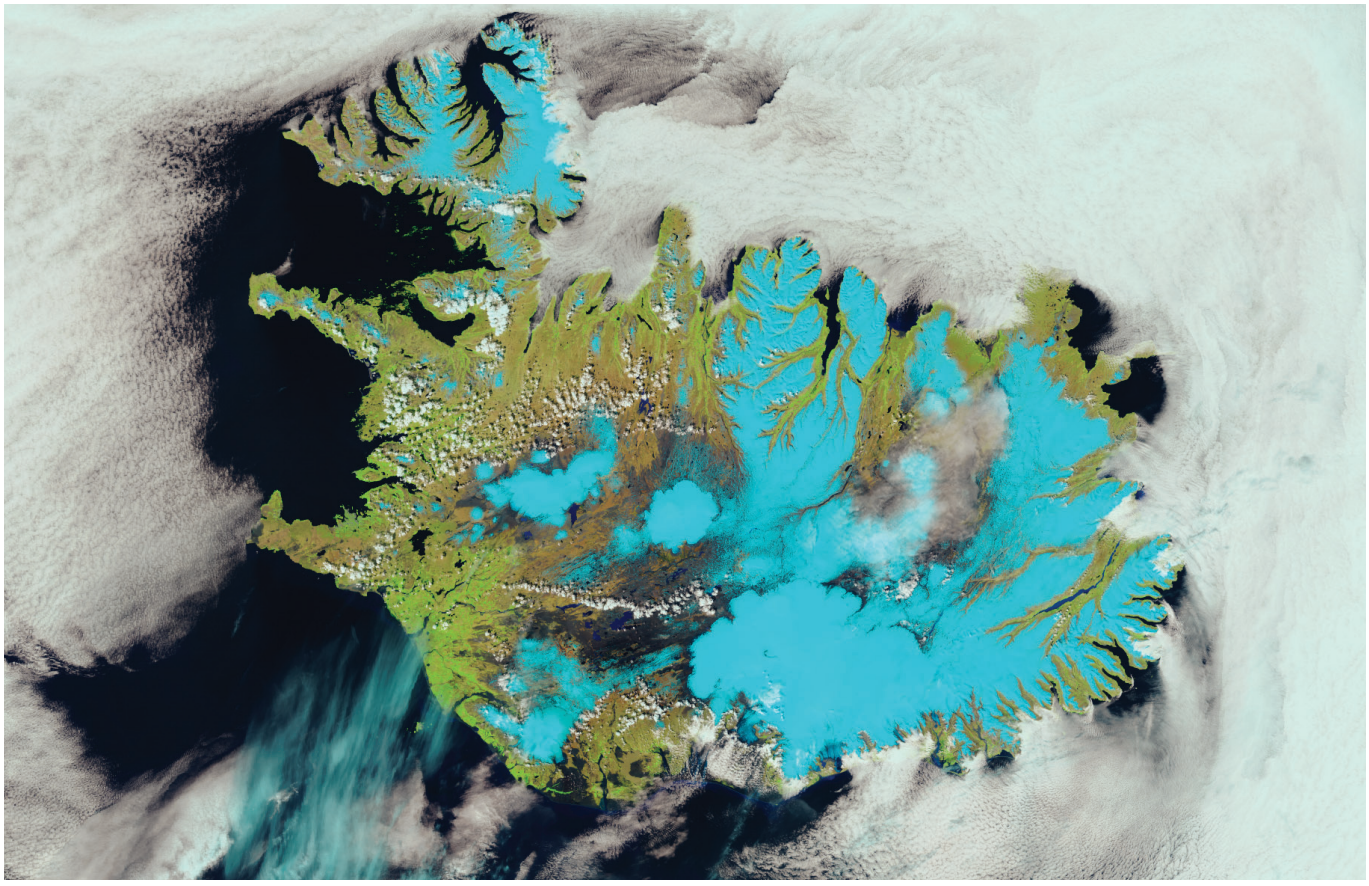


Suomi NPP VIIRS 375m resolution false colour image showing icebergs, sea smoke and brackish ice off southern Greenland

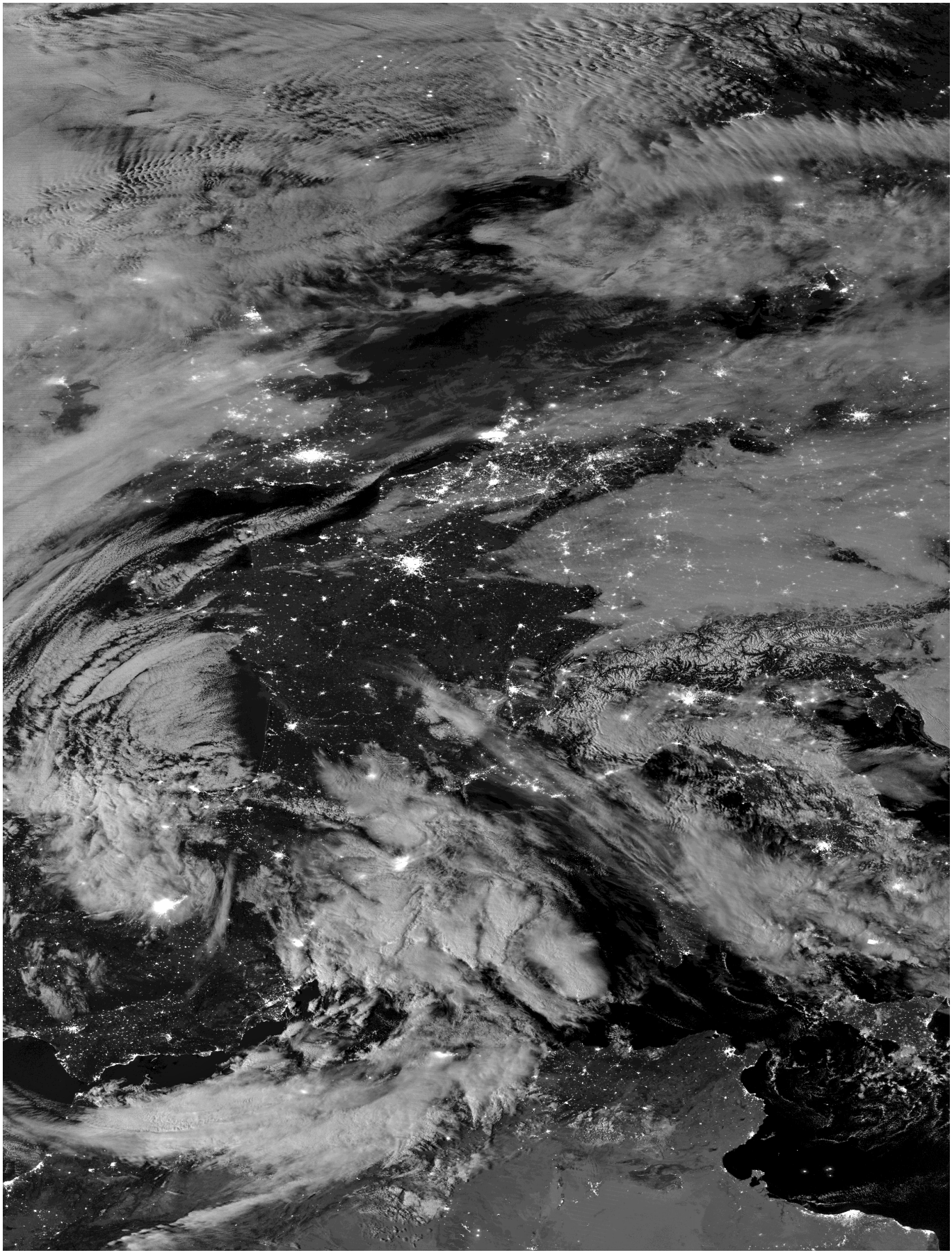
Suomi NPP VIIRS 375m resolution false colour image showing the north African coast



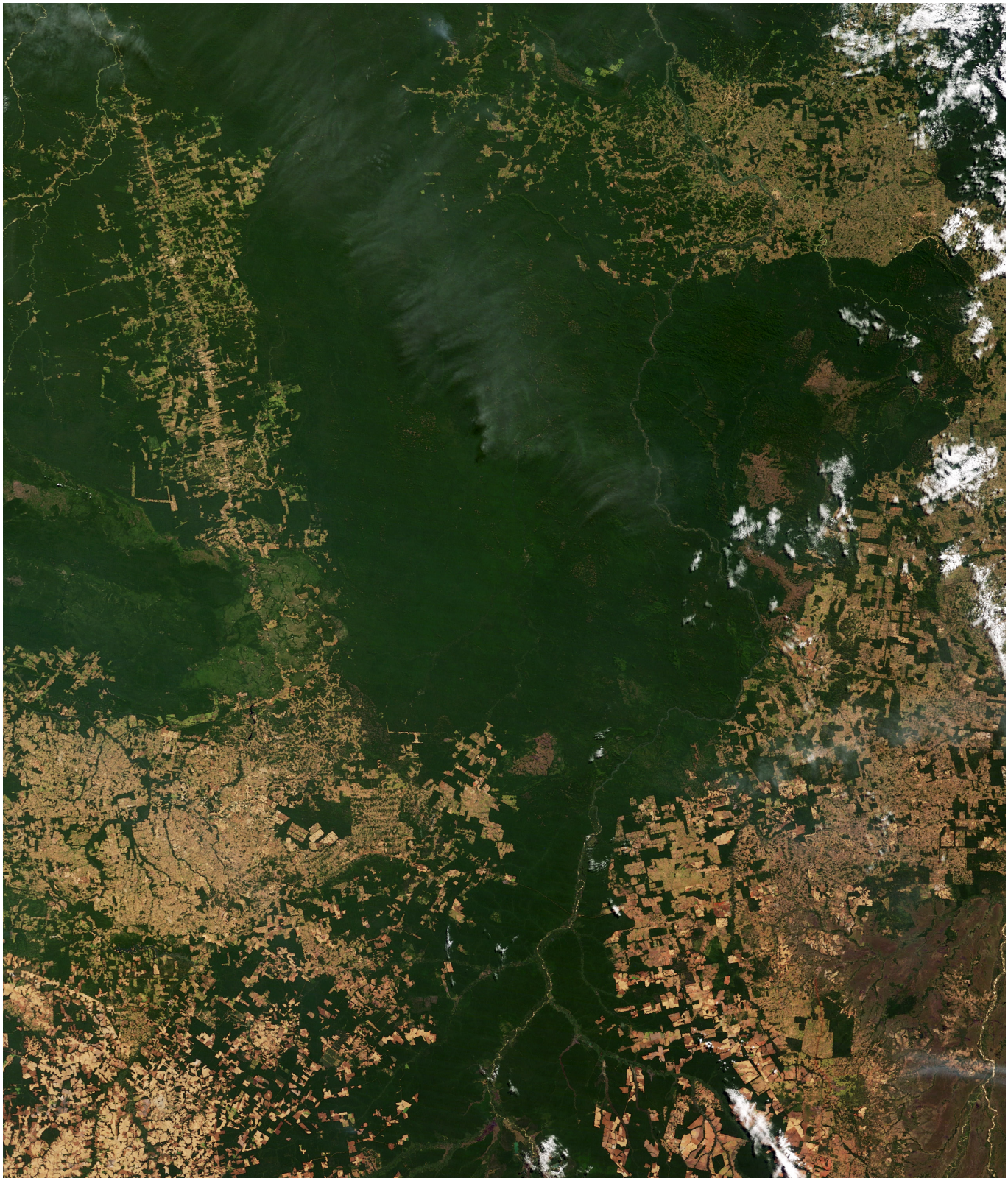
Aqua MODIS 250m resolution false colour image showing southern Iceland



Suomi NPP VIIRS 375m resolution false colour image showing Iceland with ice and snow appearing cyan



Suomi NPP VIIRS 750m resolution day-night band reprojected night-time image showing the effect of lunar illumination and artificial lighting in urban areas over Europe and northern Africa



Terra MODIS 250m resolution true colour image showing deforestation in the Amazon rainforest, Brazil

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