



# OBSERVATIONS

NCEO's Newsletter—Earth Observation Science to Understand a Changing Planet

December 2017

**It is a pleasure to introduce our final newsletter of the year.** 2017 has been exciting and challenging for NCEO from new satellites to the commissioning of national capability. The launch of Sentinel-5P offers a new perspective on air quality, tropospheric ozone and methane. Particular congratulations are due to Helen Brindley at Imperial and NCEO colleagues involved in the successful proposal of FORUM as one of two EE-9 candidate missions. We also congratulate Heiko Balzter, Pedro Rodriguez-Veiga and Ciaran Robb at Leicester for winning a Copernicus Master's Award, developing a mobile app for detecting deforestation. We started the year in the media spotlight with ESA's Aeolus wind mission, which headed for test and launch, and we are set to end the year similarly: Mat Disney and Phil Wilkes feature in a BBC documentary on 20th December scanning an oak tree in Dame Judi Dench's garden. Thank you for all your hard work and contributions which have transformed the belief in NCEO within NERC and across government. I wish you and your families a peaceful and fulfilling Christmas.

John Remedios, NCEO Director

## The FORUM ESA Earth Explorer 9 (EE9) candidate mission

Over the vast majority of the globe climate models predict that more than 50 % of total outgoing longwave radiation from Earth occurs within the 'so-called' Far Infrared (wavelengths > 15  $\mu\text{m}$ ). But the spectral distribution of this radiation has never been measured in its entirety from space. The Far infrared Outgoing Radiation Understanding and Monitoring (FORUM) mission seeks to fill this major observational gap. By flying in tandem with the Infrared Atmospheric Sounding Interferometer – Next Generation (IASI-NG) instrument on MetOp-SG, FORUM will also deliver the first ever combined measurements of the Earth's outgoing longwave radiation spectrum across the mid and far infrared (see figure below).

The far infrared region of Earth's spectrum is highly sensitive to variables thought to exert strong but highly uncertain feedback effects, including upper tropospheric/lower stratospheric water vapour, cirrus cloud and high latitude surface emissivity. FORUM will allow step change improvements to be made in our knowledge of these quantities while simultaneously assessing their impact on the overall outgoing longwave energy emitted to space. It will provide an invaluable resource for climate model evaluation and subsequent improvement, with the spectral dimension and coverage offering a stringent test of model ability to capture the true energetic signatures of key climate processes.

NCEO-Imperial (Helen Brindley and Richard Bantges), Reading (Richard Allan) and Edinburgh (Christophe Bellisario and Simon Tett) are involved in FORUM, which has been selected by ESA as one of two missions which will both now enter a 2 year study phase to further assess their technical feasibility and scientific merit. Following this, one will be chosen to be the 9<sup>th</sup> Earth Explorer. The final decision will be made by ESA's Member States after a User Consultation Meeting in 2019. The anticipated launch date of EE9 is 2025.

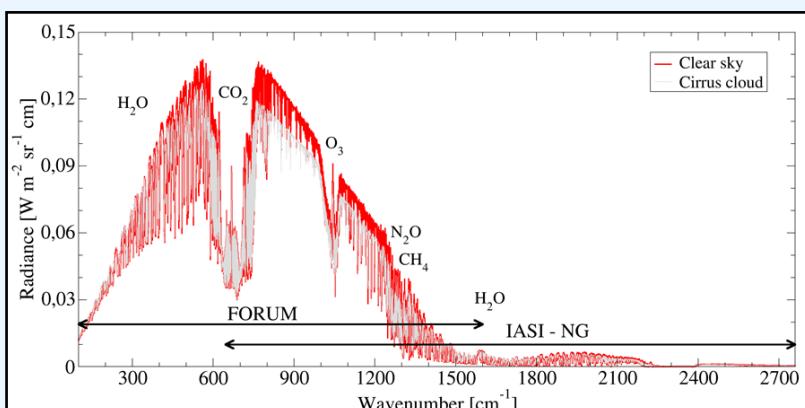


Figure (left): Two simulations of the spectrally resolved outgoing longwave nadir radiance at the top of the Earth's atmosphere across the combined range of FORUM and IASI-NG. The red case is for tropical clear-sky conditions, the grey case embeds a cirrus cloud in the atmosphere, increasing absorption and scattering and reducing the outgoing radiance. Dominant absorbers across different spectral bands are highlighted as is the spectral range of each instrument.



Left: 3D lidar point cloud of a sequoia, collected by Mat and team, Armstrong State Park, Sonoma County, California. Right: Mat standing next to a 90m+ sequoia

## Cal/val in California

Mat Disney and his team have been out in California with their NCEO-funded terrestrial laser scanner to measure the largest organisms on Earth, the coastal sequoia trees. These can live more than 2000 years and reach 115 m tall. The team were in California as part of a NASA-funded project, [Future Mission Fusion for High Biomass Forest Carbon Accounting](#). The project is providing ground data to help prepare for a new NASA-funded laser instrument, GEDI ([Global Ecosystem Dynamics Investigation](#)), which will fly on the International ISS in 2019.

GEDI will measure the mass of Carbon stored by global forests and how this is changing with climate. This requires accurate estimates of tree mass. But weighing trees is extremely difficult, so instead tree mass is usually inferred from tree height or trunk diameter, both of which correlate with mass. Consequently, global estimates of Carbon stocks and fluxes have large and potentially unknown uncertainties. Several other forthcoming EO missions will also address this uncertainty, including ESA's BIOMASS mission led by NCEO's Shaun Quegan. All these missions will rely on accurate ground data for calibrating new algorithms and crucially, for validating biomass estimates post-launch.

Mat's laser measurements capture tree volume and biomass independently of any assumptions about tree size. He is working with NASA and ESA teams to collect cal/val measurements across the tropics and elsewhere. The work in California is the first time the giant sequoias have been seen in such detail (see [interactive 3D Sketchfab model](#)), and many are larger and heavier than previously thought. NERC and NCEO's investment in capital and expertise has enabled development

of a world-leading capability for measuring forests that is proving central to cal/val for new global EO biomass missions (Mat co-leads the [CEOS LPV Biomass group](#)).

Mat and Phil Wilkes feature in a BBC documentary about British trees presented by Dame Judi Dench, to be broadcast on BBC1 on the 20th December at 8pm. They scanned an oak tree in Dame Judi's garden, and found it weighed about 25 tons, has 500,000 leaves and nearly 12 km of branches! Mat's [blog](#) has more on his work in this area. Ref: Gonzalez de Tanago, J., Lau, A., Bartholomeus, H., Herold, M., Avitabile, V., Raumonen, P., Martius, C., Goodman, R. C., Manuri, S., Burt, A., Disney, M. I. and Calders, K. (2017) [Estimation of above-ground biomass of large tropical trees with Terrestrial LiDAR](#), Methods in Ecology and Evolution, doi: 10.1111/2041-210X.12904

## NERC UnEarthed, Edinburgh

This year, NERC took its public science showcase to the visitor attraction Dynamic Earth in Edinburgh. From 17th-19th November over 7000 visitors explored more than two dozen stands, with props ranging from state-of-the-art equipment to lit-up fluffy clouds. Science buskers entertained people while they queued in the cold – at times waiting for two hours to get in.

Our joint NCEO/CEDA stand featured the Thermal infrared camera, Sentinel images, a 1:10 scale model of Sentinel 3 (courtesy of RAL Space) and a huge jigsaw of sea-surface temperatures to demonstrate the advantages of using different parts of the electromagnetic spectrum to monitor the Earth. Our antics with the thermal camera even managed to draw in some teenagers reluctant to show any enjoyment their school trip!

Poppy Townsend (CEDA) covered her kitchen in rice for the sake of outreach: she filled bottles with rice to illustrate how Copernicus satellite data volumes, and JASMIN's data capacity compared to a new smartphone. [cont. p3]

## NCEO Scientists Receive 'Space Oscar'

Heiko Balzter, Ciaran Robb and Pedro Rodriguez-Veiga received the award, for their pioneering research to reduce the devastating effects of deforestation, giving international recognition for their research that has led to a mobile app to help combat illegal logging.

The Copernicus Masters is an international competition that awards prizes for innovative solutions, developments and ideas for business and society based on Earth observation data. The prize is awarded for Forest Sentinel, a system that sends out rapid deforestation alerts to a mobile app and enables communication with hundreds and thousands of app users in the field via a central dashboard. This enables effective protection of forest assets from illegal logging.

# NCEO-PML cruise to validate Sentinel ocean products

The AMT4SentinelFRM consortium aims to provide high quality reference measurements to validate Sentinel satellite data. The objective is to class the data collected on the annual Atlantic Meridional Transect (AMT) voyage as Fidicial Reference Measurements (FRM), meaning that it is certified to meet standards of quality and confidence. NCEO's Bob Brewin and Giorgio Dall'Olmo work with Gavin Tilstone, the science lead for AMT4SentinelFRM.

Preparation for this autumn's AMT cruise started at the beginning of August, with new equipment being manufactured to improve on last year's operations and measurements. We set sail on 16th September. Gavin Tilstone and Francesco Nencioli from PML ran the optical instruments for the validation of Sentinel ocean colour; Werenfrid Wimmer from the University of Southampton ran the Infra-red radiometers and Peter Sutherland from IFREMER joined the ship in port to install the c-band radar system that characterises wave properties detected by the Sentinel 1 satellite.



AMT 27 scientists and crew of RSS Discovery (credit: Gavin Tilstone).



RSS Discovery met platform and AMT4SentinelFRM sensors (credit: Gavin Tilstone).

The transect is huge, covering 13,500km, and takes in a wide range of ocean provinces, most importantly the 'ocean deserts' in the centre of the North and South Atlantic called the oligotrophic gyres. They are warm, swirling vortexes created by wind or currents that are low in nutrients and comparatively void of life. This year we saw even fewer animals and fish compared previous AMT cruises. This is due to rising ocean temperatures, through to stratify the open ocean and reduce the availability of nutrients.

This year we were joined by Quinten Van Hellemond from the Royal Belgian Institute of Natural Sciences and

Krista Alikas from the Tartu Observatory, Estonia, who with the PML optics team are comparing long track and on station above-water radiometric measurements with different sensors. These sensors are designed to retrieve the spectral distribution of upwelling radiance just above the sea surface, used to estimate chlorophyll-a concentration as a proxy of phytoplankton biomass. Comparing different radiometers helps us understand the effects of instrument design, giving us more confidence in the data products. To facilitate these comparisons, PML designed a purpose-built frame so the sensors all have the same viewing geometry, to receive the same upwelling radiances. All the instruments are installed on the ship's met platform, with an unrestricted view of the ocean, and provided an autonomous, continuous data stream of the sea conditions and optical properties.

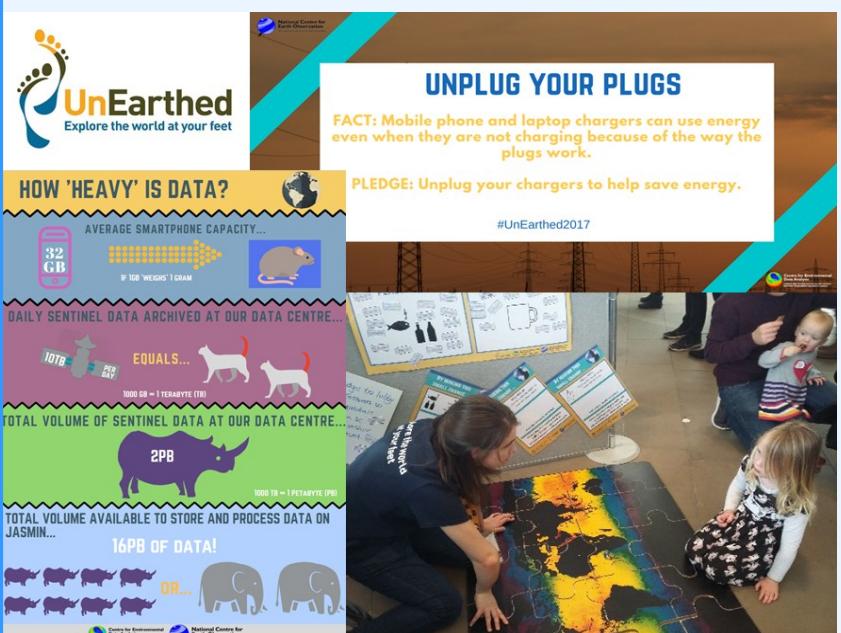
## Upcoming Events

- Researchers Forum: 5/6 February , Leicester. Registration open now
- NCEO Staff Meeting: 14th March, Leicester
- PV2018: 15-17 May, Harwell
- National EO Conference: 4-7th September, location tbc

## [cont.] NERC UnEarthed, Edinburgh

We asked visitors to pledge to make a small but effective change to 'save the planet'. Most people who added their name to our pledge wall were astounded by what we can discover with remote sensing, by the amount of data available and its applications (for example for model validation). People wanted to hear from and interrogate scientists, and it gave the researchers an opportunity to listen too. And have great fun too!

Thank you to all of the volunteers who helped run the stand: your enthusiasm was fantastic and we really appreciate the time spent helping out.



## Send us your stories for the newsletter

Please send any news stories for the newsletter to Rosie Leigh [rg82@le.ac.uk](mailto:rg82@le.ac.uk) or Sophie Hebden [sh631@leicester.ac.uk](mailto:sh631@leicester.ac.uk)

# Five minutes with...Caroline Poulsen

In this issue we asked Caroline from NCEO RAL Space STFC and Defra five questions about herself and her work...



## Caroline, tell us a bit about your work...

I work in RAL Space at STFC. In my research for NCEO I work on retrieving the properties of clouds and aerosols from visible to Infrared passive satellite instruments. I am particularly passionate about the ATSR-SLSTR series of instruments. It is great to work in a department that is involved in the full cycle of a satellite instrument from design, build, calibration, data archive to science.

This year I have been seconded to Defra 3 days a week where I am working with the chief scientist's office and the environment analysis unit, I have been working to develop links between Scientists in the data programme, Defra Earth observation Centre of Excellence and the Air Quality unit. It's been fascinating to see how satellite data is used to deliver operational services and develop policy.



## What are the motivations for your area of research?

Clouds and aerosols, how their properties are varying in time and how they interact is one of the least understood areas of climate change and contributes to the largest uncertainties. Long time series of satellite aerosol and cloud records from instruments such as ATSR/SLSTR and AVHRR can help improve our understanding.

## Can you describe an image from your work?

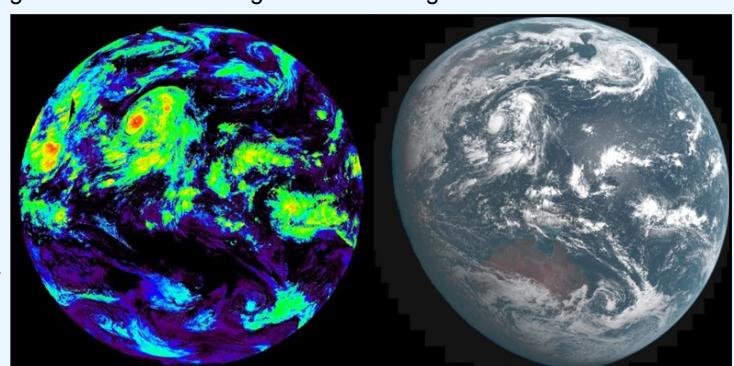
In December STFC hosted a visit by the permanent secretary of Defra, Clare Moriarty and staff from the Defra Earth Observation centre of excellence and the Defra data programme. She visited the RAL Space test facility and Jasmin and met with NCEO employees. It was great to see the work I have been doing to connect academia and Defra begin to bear fruit. She is pictured here with the director of RAL Space Chris Mutlow in the RAL space instrument test facility.

## What inspired you to work in your current research area?

My PhD was in particle physics which was great fun, however when I finished my PhD I decided I wanted a job closer to my interests which was climate and the environment. Working with satellites was a great fit as I still got to work with lots of data and world leading instruments.

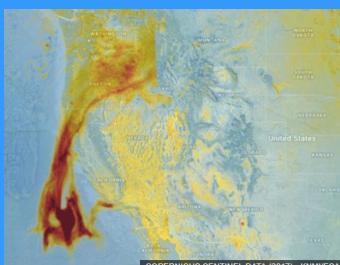
## What is your favourite image of the Earth from space and why?

It is hard to pin down any single image however currently I am particularly fond of this image of Cloud top height, retrieved using the ORAC algorithm from Himawari. Not only is Himawari- AHI a beautiful instrument but it images Australia which is where I am from.



## Also in the news...

- First data from S-5P is presented at AGU showing smoke plumes from Californian wildfires (image right) (<http://www.bbc.co.uk/news/science-environment-42375062>)



- Amazon's recovery from forest loss limited by climate change according to a study published by Williams and Exbrayat at NCEO Edinburgh (<https://www.nceo.ac.uk/article/amazons-recovery-from-forest-losses-limited-by-climate-change/>)