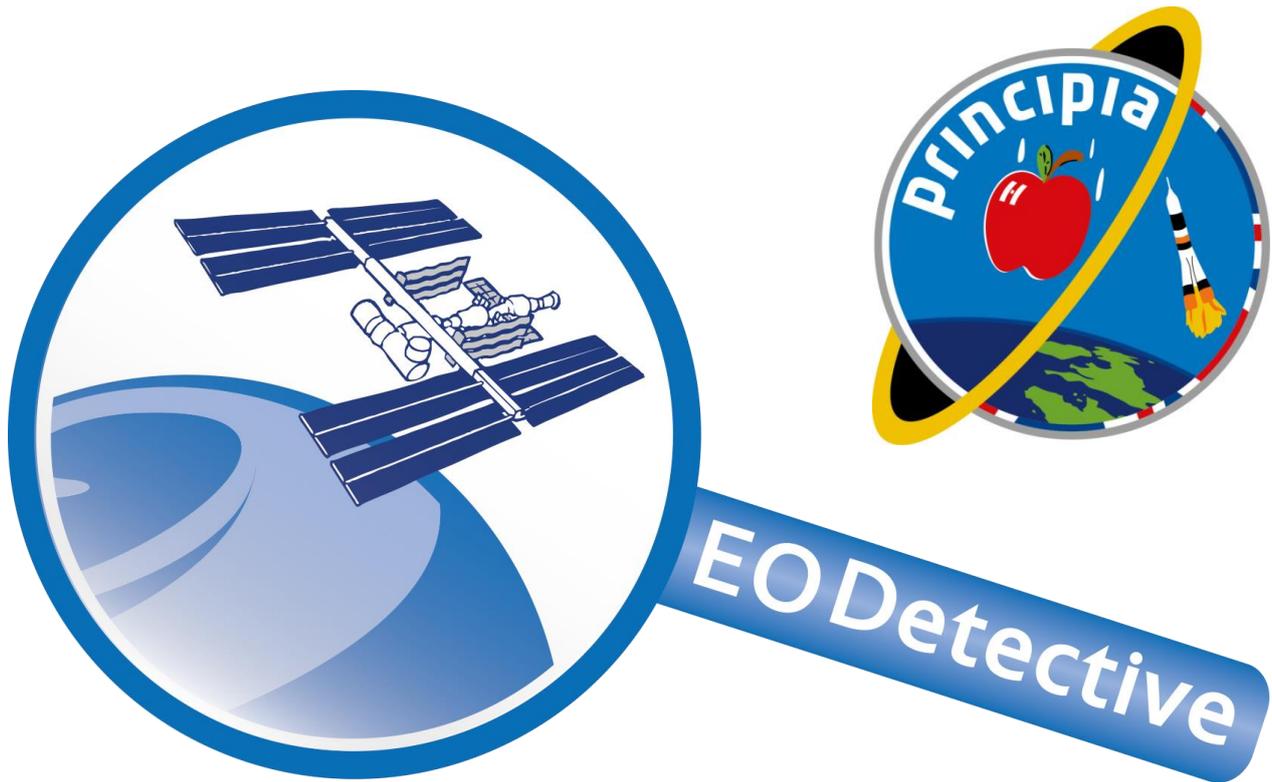


principia

BRITISH ESA ASTRONAUT TIM PEAKE'S MISSION



EO Detective

Observing the Earth from space

Teacher guide – key stage 2



**National Centre for
Earth Observation**
NATURAL ENVIRONMENT RESEARCH COUNCIL



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Introduction



Astronauts have been taking photographs of the Earth from space for over 50 years and Earth observation scientists have used satellite images for a similar amount of time. The EO Detective activities aim to demonstrate how a vantage point in space, such as the International Space Station, provides a unique perspective from which people can monitor environmental processes and change.

This resource is aimed at teachers of key stage 2 pupils and is closely linked to elements of the mathematics national curriculum, as well as supporting aspects of science, geography and computing. The activities use early astronaut photographs to encourage students to think about what features on the Earth look like from space, and satellite images to enable students to measure the growth of a city and the shrinking of a glacier.

The activities are flexible: each can be used in a variety of ways, either by itself or as part of a longer session or sequence of lessons, and the resources lend themselves to several extension activities and further discussion.

Further information

The worksheets, presentations and other materials which go with this resource are available from the European Space Education Resource Office (ESERO) Tim Peake page, which is hosted by the National STEM centre. You can go directly to the main EO Detective page at <http://stem.org.uk/cx46j> Please share with other teachers how you have used these materials by adding a comment on the appropriate resource.

More details about the national competition based on these activities are available from the Principia mission website, at <https://principia.org.uk/activity/eodetective/>

If you have any other questions or feedback, please contact EODetective@le.ac.uk

A note about colour

While the images used in these materials are presented in colour, it is still possible to see the detail necessary if they are reproduced as greyscale images. The activities should therefore be accessible to pupils with colour vision deficiency or/and if the materials are photocopied in black and white.

Resources produced by Catherine Fitzsimons from NCEO with support of the organisations below.

Thank you to teachers who attended the ESERO-UK Primary and Secondary Conferences in July 2015 and the 2015 Space as a Context for Teaching Science CPD in 2015 for their feedback and to Mrs Christian Duckworth and pupils from St Mary and St Andrew's Catholic Primary School, Barton, Preston for their suggestions.





Curriculum coverage

The list below outlines the main curriculum points covered if the activities are worked through in sequence. Extension activities may cover further topics. The wording is taken from the National Curriculum for England for 2015–16, but similar areas are covered by many other programmes of study and curricula.

Maths

Years 3–4

- find the area of rectilinear shapes by counting squares
- describe positions on a 2-D grid as coordinates in the first quadrant

Years 5–6

- recognise when it is possible to use formulae for area of shapes
- estimate the area of irregular shapes
- add and subtract fractions with the same denominator and denominators that are multiples of the same number
- multiply proper fractions and mixed numbers by whole numbers
- solve problems involving multiplication

Science

Years 3–4

- use results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions

Years 5–6

- report and present findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations

Geography

- describe and understand key aspects of:
 - physical geography, including: climate zones, biomes and vegetation belts, rivers, mountains
 - human geography, including: types of settlement and land use, economic activity including trade links, and the distribution of natural resources
- use the eight points of a compass, four and six-figure grid references
- use fieldwork to observe, measure, record and present the human and physical features in the local area using a range of methods, including sketch maps ... and digital technologies

Computing

- understand computer networks including ... the opportunities they offer for communication and collaboration
- use search technologies effectively, appreciate how results are selected and ranked, and be discerning in evaluating digital content

From the ground and from the sky



This activity **introduces the idea of remote observation** by asking students to match photographs taken from the ground with early astronaut photographs. The table could be completed as a **preparatory homework** or as a **starter activity**, or there could be more detailed discussion of the individual images and questions. This activity is also suitable for key stage 1 students, as it reinforces the use of geographical vocabulary to refer to physical and human features and extends the idea of recognising features in aerial photographs.

Resources

- The **presentation** for this activity can be used by itself or alongside the worksheet.
- The **worksheet** for this activity is available with and without the context, instructions and questions.
- The images could also be presented to students on cards, made by printing the appropriate slides from the presentation.

Suggested sequence

1. Talk about looking at the Earth from a spacecraft such as the ISS, shown in the logo on the title slide. Have the students seen any pictures taken from space? What do they look like?
2. Discuss Pictures 1 and A. How do we know they are both of mountains? What things are similar? Different? (E.g., detail, clouds, sharp edges, vegetation.)
3. Students complete the table using the other photographs. They could do this individually or in pairs using the worksheet, or you could show the slides in sequence and students could have a few moments to decide where to put the letter/number in a copy of the table.
4. Compare/check answers (shown below and on slides 15–20). Which were tricky? (The earth photos of the lake and river are difficult to distinguish because both have distant banks/shores. The city might be hard to distinguish in the astronaut photo because the countryside around it has similar colours.)
5. Ask students to work in groups to compare a pair of photographs using the questions on the sheet/slide 21.
6. As students from each group report back, produce a list of key words from their comments.
7. Ask students to use this list to help them write down why and when pictures of the Earth taken from space are helpful, perhaps using the sentence starters on slide 22.

Answers

(see table)

Place	Earth picture	Astronaut picture
Mountains	1	A
A desert	5	C
An island	4	B
A city	2	F
A lake	6	E
A river	3	D

Additional activities and questions

Each of the images in this activity could be **discussed in more detail**. For example:



- What do you think makes the circular shape in the middle of the island you can see most clearly in picture B? (Volcano.)
- Would this island look like the one in picture 4?
- What about the other pairs: can you tell if any are definitely (or are definitely not) of the same locations, rather than just the same type of place? Why, or why not? (The desert, lake, river and mountain pictures are, but without e.g., GPS data, it's difficult to decide.)
- Can you identify the country in picture C? (Oman.)
- What is the patterned bit at one end of the lake in picture E? Why is it in just this place? (Farmland. Surrounding area is desert and this area has a higher water table or/and is easier to irrigate.)

What countries are shown in the images on Slide 2? How are they different to a map (print or/and electronic)? How do you think images like this help **cartographers**?

If there is a suitable **viewpoint** locally, (e.g., a balcony, a tall building, or hill) students could compare their own images of a particular feature (e.g., the school) taken from the top of this and from ground level, perhaps then comparing with aerial photography to discuss side, oblique and plan views.

Most of the images used in this activity are from Gemini and Apollo missions in the 1960s, and those on slide 2 are from Skylab in the 1970s (see below for details). Students could research the various manned space missions that have taken place finding out things such as the dates, crew and purpose of each mission to present to each other or/and add to a **human spaceflight timeline** together with a [photograph of earth](#) taken on each mission.

There is a picture on slide 3 of the camera used to take Picture A. How have **cameras**, and the images they produce, changed since 1965? Is there a local photographer or photography club that could bring in a variety of cameras for students to look at?

Viva Las Vegas!



This **main activity** shows **how EO can be used to study human geography**. It asks students to measure the area of Las Vegas at three separate times over the last few decades, predict its current extent and then check their prediction. The demand of the activity can easily be altered for students in different year groups and used as an interesting way to teach, consolidate or review the measurement of irregular areas or/and addition and multiplication of fractions.

Resources

- **A5 images** of a 78km × 54km area centred on Las Vegas for 5 different years (4 for the main activity) are available in three different formats: with a 5km × 5km grid (which may be easier for younger students to use), with a labelled 4km × 4km grid (which makes fractions easier and allows work with coordinates) and with no grid (which may be easier to use when describing the general area). **Grids** are also available for printing on to transparency.
- The **presentation** uses the labelled 4km × 4km grid, but the other versions can be cut and pasted from the image sheets into the slides.
- The **worksheet** for the core part of the activity is available in two versions: one which uses counting whole squares only, and another which includes counting and adding up fractions of squares.

Suggested sequence

1. Talk about looking at cities from space. What level of detail would we expect to see? How could we tell a place is a city? How would it compare with a map? What would it look like at night?
2. What do students know about Las Vegas? What can they find out from slide 3 in the presentation?
3. Discuss how we can compare the area of the city at different times or/and measure its area using satellite images.
 - Y3&4: use a grid and count the number of squares that are (or are mostly) city.
 - Y5&6: for part-filled squares, estimate fraction filled (worksheet suggests limit to quarters and halves), add results, and multiply by area of a single square.
4. It may help to draw an outline around the city first.
5. Use the 1982 image on slide 4 to demonstrate how to do this or, if it is a consolidation lesson, distribute this image with the others.
6. Give each student an image of Las Vegas in 1990 or 2000 and ask them to find the area using the appropriate technique.
7. Ask students to pair up with someone who had a different image (or get into 3s if 1982 image distributed) and look at the sequence of answers. What has happened to Las Vegas over the last few decades? Why do they think this has happened? What do they think the area is now, in 2015?
8. Distribute the 2015 images for students to use to check their estimates.
9. Ask students who made good estimates to share their reasoning with the class.

Answers

The current 'official' value for the area of Las Vegas is 352km² (so around 22 4km × 4km squares or 14 5km × 5km squares). Students are likely to get a much larger answer than this as there are 'holes' in the city which are difficult to see on an A5 image or/and account for working at this scale. Answers for earlier years will vary in a similar way, but [a published analysis of the 1973 photograph](#) yielded an answer of 206 km², so this might be considered a lower limit.



Additional activities and questions

There is also a **1973 astronaut photograph** of this area, printed at the same scale, so students could also extrapolate backwards. This isn't used as part of the main activity because the colours look different, which itself could be a discussion point.

Students could **plot charts or graphs** to show the spread of their results or/and help predict the 2015 area and so begin to appreciate ideas about making multiple measurements and reliability of results and non-linear changes.

Using the images with coordinates, students could:

- **locate particular features** such as the airport, golf courses, the separate town of Boulder City, islands in Lake Mead or (harder) the Hoover Dam (it isn't visible on the images, although the races at either side can just about be seen in some, but its position can be inferred by looking at where the river leaves the lake).
- when estimating the 2015 area, **describe where the city will grow**, using compass points and coordinates.

Why do you think Las Vegas was chosen for this activity rather than, say, London? Which city can astronauts on the International Space Station get a better photo of? Why? (The path taken by the ISS means that is unable to take 'straight down' photographs suitable for measurements for much of the UK. Although the same is not true of satellites, they are still affected by clouds which are far more common in Britain than Nevada. There are also differences between the US and UK to do with land availability, planning policies and so on, which affects the rate and type of growth.)

Students could **use the [ISS tracker](#)** to work out which cities the ISS is due to pass over and set an alarm to watch the live feed as it does so.

How else can you find out if towns/cities have grown? Has your (nearest) town/city changed as much as Las Vegas? Which cities have? Why do some places grow and others not? Students could research a particular city individually or in small groups to create a presentation or display about growing or/and shrinking cities. Using 'fastest growing cities' as a search term brings up a range of sites which vary considerably in presentation and scope. Which are most useful? Most reliable?

The lake in the picture, **Lake Mead**, is an artificial lake that has also visibly changed size over the last 15 years. As well as measuring this change (perhaps using a smaller grid) students could find about the history and purpose of this reservoir or/and other reservoirs related to places they are studying.

Watching a glacier



This activity shows **how EO data is used to monitor environmental change** and also asks students to measure irregular areas in a sequence of pictures, this time bright false-colour composites created from satellite data. As there are a smaller number of images, there is less emphasis on prediction, so this could be used **to introduce the mathematical ideas** prior to *Viva Las Vegas!* or students could be given it as an **extension activity** with fewer explicit instructions.

Resources

- **Sets of images** showing the Columbia glacier in three different years are available without a grid and with grids of two different sizes (4km × 4km and 2km × 2km). Each set prints out on an A4 sheet that also includes a key and some questions, so this can be used as a prompt or used to produce cards for individual images. The area covered in each image is 26.25km × 45km.
- The **presentation** includes additional true and false-colour images of the region at a later time of year.

Suggested sequence

1. Talk about glaciers with students. (*Ice Age* may be a good place to start.) What are they? Why are there fewer now than at some times in the Earth's past? Where do we find them today?
2. Ask students if they can point out individual glaciers in the image on slide 2. What is the area around them like? This picture is from the summer, what do they think the area would look like in the winter?
3. Discuss the problems with working out what is what in the picture: not all the white bits are snow or ice (some are clouds), it's hard to see the coastline (because green forest and brown land are a similar shade to water, especially if the water is murky).
4. Show the real and false-colour images on slide 3 (but not the key or grid yet) and explain that EO detectives use computers to make coloured images from data sent down by satellites. These can look like normal photographs or very different. Ask students to try to work out what the colours in the second image represent before showing the key.
5. Add the grid to the image and ask students to identify a square with lots of clouds, a square that is mostly ocean, one with lots of plants and so on.
6. Give or show students the images of the Colombia glacier from 1989, 2005 and 2015 and ask them to work in small groups to investigate and describe what has happened to it in as much detail as possible. Encourage them to measure the area, add numbers to the grid so they can locate features and use tables, charts and sketches to present their results.
7. Compare answers across groups, discussing why scientists think this is happening.



Answers

These will, of course vary, but the area of the glacier in the region shown has decreased from around 300km² in 1989 to less than 150km² in 2015 – how much less depends on whether or not students consider the two main branches alone or include other now isolated regions of ice.

Additional activities and questions

The Columbia glacier empties into Prince William Sound near Valdez, Alaska. Can students find this on a map or Google Earth? How are **coastlines** shown in areas like this? How do geographers decide where the coast is if it's always covered in ice? Do they count the edge of the ice (at a particular time of year?) as the coast or do something else?

In this exercise we haven't asked for a prediction to be made about the area of ice in 2015. Why? (Only two other data points, much more likely to be variable in either direction than the extent of a city.) There are other cloud-free, or nearly cloud-free images of the Columbia glacier available, so why couldn't we use them? (We need all images to be from the same season.) In what other investigations might the **evidence** available to EO Detectives be **limited** in this way?

This region is popular with tourists. What do they come to see? What can they do at different times of the year? What plants and animals live in the area? Students could work in groups to create a **brochure** or **advertisement for a tourist company**, or a **script for a tour guide** on a cruise, perhaps pointing out the effects of these changes on the wildlife of the region.

Students could search for other **false-colour satellite images** and identify what features show up better using the colour system that has been chosen. They could make a poster comparing the image they have found with an astronaut or aerial photograph of the same region.



Where would you photograph?

This activity gives students the opportunity to consolidate what they have learnt using these resources and practice writing to persuade and, as such, would be a good **homework activity**. However, it also works as a **standalone exercise**. In 2015–16, it forms the basis of the national EO Detective competition (see details on principia.org.uk). It is therefore ideal for use as a **class or school competition**, which you could also run prior to sending the entries on to the national competition.

Resources

- The *Image request form (worksheet)* is a condensed version of the competition **entry form**, and so the table includes two questions which are not needed for KS2 students. You could amend the sheet to remove these or use as an opportunity to teach about reading forms carefully when filling them in. (You might also choose to remove the part on finding a detective number.)
- Instructions about how to fill in the form are included in the **presentation**.
- There is a **sample request** which can be used for reference or shared with students.
- There is a **certificate** signed by the director of NCEO ('the boss of the EO Detectives') for the winners of class or school competitions.

Suggested sequence

1. Ask students what part of Earth they would take a photograph of if they went up to the International Space Station, like Tim Peake (shown on slide 2).
2. Explain that the crew of the ISS take their own photographs from the cupola (as shown on slide 3), but EO Detectives on the ground can ask for particular ones to be taken. However, to do so they have to submit a research proposal and not every request is granted because the astronauts have lots of other science to do.
3. Students are going to play the part of EO Detectives and submit their own image requests. (Give details of class/school/national competition as/if appropriate.)
4. Discuss the limitations of using the ISS for EO – some areas of the Earth are not covered, as shown on slide 4.
5. Slide 5 shows several photographs of Townsville, Australia. Ask students to discuss which they think is most interesting? Useful? Attractive?
6. Use these images to point out the effect of time of day/light levels (picture 4 is obviously at night, picture 2 seems to have been taken later in the day than picture 3), angle (most are 'straight down' but 1 is at a greater angle), cloud cover (picture 2 has medium cloud cover) and area covered/detail they can see.
7. Ask students to decide if each of the features listed on slide 6 would be possible or difficult to see in photographs taken from space. This could be done by asking them to choose where to stand along a line depending on how certain they are/how well they think it would show up. (Answers show via animated icons.)
8. Ask students to share ideas about what they might be able to find out from a photograph from the ISS, perhaps relating back to the places they suggested at the start.



9. Ask students to work on their research request, using slide 7 or/and the form. This part of the activity could be done in groups or at home, although it will require the use of an atlas, GIS or the internet to determine the latitude and the longitude and possibly some further support with the form.
10. Students can peer review each other's submissions, checking that the co-ordinates are correct and using the criteria on slides 7 & 8 to support their feedback as well as carrying out the usual evaluation and editing tasks.
11. (Later, if appropriate.) Announce the winner(s) of any internal competition and present certificate or/and prizes!

Answers

It is possible to get good photographs of: mountains, cities, forests, clouds, rivers & fields (although narrow rivers and small fields may not show up well). These won't show up well in photographs: people, cars, houses and boats (except very large houses and very big boats e.g. container ships and cruise liners).

Additional activities and questions

What can students find out about aspects of **living on the ISS** that are mentioned here such as: How much free time do the crew get? How much of their own equipment can they bring up? How long is a working day (the crew see 15 or 16 sunrises and sunsets every day)?

The image on slide 4 shows two orbits of the ISS: can students work out what country it is going over? Can they work out the path of the **next orbit** and add it to the image? The picture comes from the [ESA tracking website](#). Students could use the current image from there for this exercise, using the map below to check the country and returning to the site later to see if the path has changed in the way they expect. They could also suggest what the HDEV camera might be showing before scrolling down to see.

Can students find evidence to support their answers to the question on slide 6 by searching for **astronaut photographs** that do, or would if they were detailed enough, show the feature? Can they offer other suggestions for things which can/cannot be seen?

Can students identify the island on slide 7?

Students could carry the model further by working in groups to review the proposals of students from another group and discuss which request they think should be granted. This would give further opportunities for evaluation as well as **debate**. They could also search to see if any photographs matching their criteria already exist and, if so, compare them to what they were expecting, or and use them answer their questions.

This exercise could be adapted for **KS1 students** by, for example, getting them to find their target area using mapping software and taking a screenshot rather than identifying latitude and longitude. You might also want to omit some of the ideas about angle and resolution for younger students.

Additional resources and materials



Astronaut photographs

The primary source for astronaut photographs of Earth is NASA's *Gateway to Astronaut Photographs of Earth* <http://eol.jsc.nasa.gov/SearchPhotos/>. These photographs can be used for educational purposes free of charge.

Photographs tweeted by astronauts the ISS between November 2014 and May 2015 are mapped at

<http://www.arcgis.com/apps/OnePane/basicviewer/index.html?appid=31b4fec136714cd6b99781cc7732a033> and the details pane provides links to similar maps for earlier missions.

You could also search on [flickr](#) for individual astronauts (such as Alexander Gerst who has an *Earth from Space* album

https://www.flickr.com/photos/astro_alex/albums/72157644973526292) although many of these do have copyright restrictions.

Satellite images of Earth

Both ESA and NASA have regularly updated Earth Observation image sites where they publish interesting and often spectacular, images of Earth, with commentaries. These are at http://www.esa.int/spaceinimages/Sets/Earth_observation_image_of_the_week and <http://earthobservatory.nasa.gov> respectively. Once again, you can download and use the images for educational purposes free of charge.

There is some useful guidance on understanding satellite images in this blog post:

<http://earthobservatory.nasa.gov/Features/ColorImage/> much of which is also applicable to interpreting astronaut photographs.

Satellite data

You can search for unprocessed data from Landsat satellites on two US Geological survey websites: EarthExplorer (<http://earthexplorer.usgs.gov>) and Global Visualization Viewer, or GloVis (<http://glovis.usgs.gov>). The latter is, perhaps, more intuitive but can be rather slow to load.

Where is the International Space Station?

ESA's ISS tracker maps the position and current orbit of the ISS and shows a more detailed map of the area beneath it.

http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/Where_is_the_International_Space_Station There is also a live feed from a camera on the ISS which, when there is radio contact, shows the actual view from the ISS from one of four cameras. (More details about these can be found at <http://eol.jsc.nasa.gov/HDEV/>)

Principia mission

More information about Tim Peake and the Principia mission is available from principia.org.uk which also hosts a blog and gives information about other ways in which

you and your pupils can get involved. Other educational resources are available from ESERO's Tim Peake page, hosted by the National STEM centre at esero.org.uk/timpeake



Cities

http://www.citymayors.com/statistics/urban_growth1.html has a table showing the projected growth rates of cities around the world. Information from this and other tables on the site could be used to find, for example, how quickly-growing cities are distributed over the globe (tallying counts by country) or how they are distributed around the United Kingdom, perhaps by plotting them on an outline map (free printable maps are available from <http://www.d-maps.com/>).

The Belgian site EO Edu site <http://eoedu.belspo.be/en/profs/index.htm> hosts a European capitals game, where students get to see satellite imagery of each capital as they drag its name to the correct country (requires Flash). The game is also available in French ...

Glaciers

The **KS3 EO Detective materials** also include a *Watching a glacier activity*, which makes use of a larger number of images of the Columbus glacier, asking students to consider which should be compared if measurements are to be made.

The Earth section of the esa kids website <http://www.esa.int/esaKIDSen/Earth.html> includes sections on climate change and ice caps as well as some information about some of the satellites used to collect data (although the reading level of this is quite high).

Other uses of Earth Observation

Meet the EO Detectives is a series of posters/leaflets that supports this resource by introducing students to the work of a number of NCEO Earth Observation scientists.

For a broader perspective, you might want to make selective use of ideas or images from the case-study leaflets on <http://eoedu.belspo.be/en/profs/index.htm>. There are also many commercial firms that process and analyse EO data, so their websites may be a good place for students to start investigating how else such data is used. These include:

<http://www.satimagingcorp.com/applications/> <http://www.terraserver.com/solutions.asp> and <https://www.digitalglobe.com/industries> and the blog at <http://www.pixalytics.com/> is often interesting. (Note that these companies are listed only because of the format of their site – no endorsement of their services is implied!)

If you have any other useful links or ideas, please do share them with other teachers on the pages from which you downloaded this resource, or pass them on by e-mailing EODetective@le.ac.uk.

Image sources and acknowledgements



Astronaut photographs

Courtesy of the Earth Science and Remote Sensing Unit, NASA Johnson Space Center and obtained from <http://spaceflight.nasa.gov/gallery/> [NASA], or courtesy of ESA/NASA and obtained from <http://www.esa.int/spaceinimages> [ESA/NASA] unless otherwise stated

From the ground and from the sky

- A **Himalayas** Gemini 5 S65-45717 (21–29 Aug 1965) [NASA]
- B **Canary islands** Gemini 6 S65-63150 (16 Dec 1965) [NASA]
- C **Oman** Gemini 4 S65-34661 (3–7 Jun 1965) [NASA]
- D **White and Blue Nile** Apollo 7 AS7-06-1718 (14 Oct 1968) [NASA]*
- E **Salton Sea** Gemini 5 S65-45748 (21–29 Aug 1965) [NASA]*
- F **Huston** Apollo 9 AS09-22-3463 (9 Mar 1969) [NASA]*
- Slide 2 **England and Wales** Skylab 3 SL3-121-2445 (Jul–Sep 1973) [NASA]
- Slide 2 **Greece** Skylab 3 SL3-121-2367 (Jul–Sep 1973) [NASA]
- Slide 3 **Gemini 5 photographic equipment** S65-43482 (20 Aug 1965) [NASA]
- Slide 21 **Las Vegas** Skylab 3 SL3-28-059 (Jul–Sep 1973) [NASA]

Viva Las Vegas!

- Slide 9 **Las Vegas** Skylab 3 SL3-28-059 (Jul–Sep 1973)

Where would you photograph?

- Slide 2 **Tim Peake training at JSC** ESA ID 342296 [ESA/NASA]
- Slide 3 **Samantha working on BRICS** ESA ID 339612 [ESA/NASA]
- Slide 3 **Samantha in Cupola** ESA ID 335193 [ESA/NASA]
- Slide 5 **Townsville 1** Shuttle Columbia (Mission 93) STS093-709-13 (25 Jul 1999) [NASA]*
- Slide 5 **Townsville 2** ISS (Mission 5) ISS005-E-21063 (9 Nov 2002) [NASA]*
- Slide 5 **Townsville 3** ISS (Mission 5) ISS004-E-5730 (Jan 2002) [NASA]*
- Slide 5 **Townsville 4** ISS (Mission 36) ISS036-E-13557 (30 Jun 2013) [NASA]

Ground-level photographs

From [flickr](https://www.flickr.com/photos/bbalaji/4637438533) and reproduced under creative commons licences unless otherwise stated.

From the ground and from the sky

- 1 **Himalayas** B Balaji <https://www.flickr.com/photos/bbalaji/4637438533>
- 2 **Downtown Dallas** Susan Adams <https://www.flickr.com/photos/susanad813/1803752788>
- 3 **Confluence of the Nile** joepyrek <https://www.flickr.com/photos/joepyrek/8295695470>
- 4 **Island with clear waters** Chris Isherwood <https://www.flickr.com/photos/isherwoodchris/3382991517>
- 5 **OMAN Wahiba Sands** Sylwia Pecio <https://www.flickr.com/photos/59037616@N02/15144630176>



- 6 **Salton Sea pano 1** Akos Kokai
https://www.flickr.com/photos/on_earth/1452308744
- Slide 15 **Vegas Skyline** Filipe Fortes
<https://www.flickr.com/photos/fortes/138603740>
- Slide 22 **Tim Peake** UK Space Agency
<https://www.flickr.com/photos/spacegovuk/8757791230> (used with permission)

Viva Las Vegas!

- Slide 2 **Vegas Skyline** Filipe Fortes <https://www.flickr.com/photos/fortes/138603740>

Satellite data

Landsat data courtesy of USGS, obtained through <http://glovis.usgs.gov/> and <http://earthexplorer.usgs.gov> and processed by Fenner Holman of King's College, London or/and Catherine Fitzsimons of NCEO.

Viva Las Vegas!

Satellite	Instrument	Date	Path/Row	Bands
Landsat 4	TM	12/12/1982	039/035	321
Landsat 5	TM	16/05/1990	039/035	321
Landsat 7	ETM Plus	03/05/2000	039/035	321
Landsat 8	OLI	03/04/2015	039/035	432

Watching a Glacier

Satellite	Instrument	Date	Path/Row	Bands
Landsat 5	TM	01/05/1989	067/017	342
Landsat 7	ETM Plus	24/06/2000	067/017	542†
Landsat 7	ETM Plus	24/06/2000	067/017	321†
Landsat 5	TM	27/04/2005	067/017	542
Landsat 8	OLI	23/04/2015	067/017	653

Other

Viva Las Vegas!

- Slide 3 **Maps** from <http://www.freeusandworldmaps.com/index.html> (royalty-free maps)
- **Data** relating to 1973 photograph from *Dynamic Earth Environments: Remote Sensing Observations from Shuttle-Mir Missions*. Kamlesh P. Lulla and Lev V. Dessinov (eds). John Wiley & Sons, 2000.

Where would you photograph?

- Slide 4 **Screenshot** from http://www.esa.int/Our_Activities/Human_Spaceflight/International_Space_Station/Where_is_the_International_Space_Station CAF (0912 25 Aug 2015)
- Slide 7 **Corsica** Landsat 8–OLI ESA ID 334294 (29 Aug 2014) obtained from <http://www.esa.int/spaceinimages> [USGS/ESA]
- Slide 9 **ISS** Catherine Fitzsimons, based on image from NASA's *321 Lift off!* (Education resources)

Images marked * have been cropped to areas of interest by CAF