



2–7 December 2019
Melbourne, Australia



10TH ASIA-OCEANIA METEOROLOGICAL SATELLITE USERS' CONFERENCE

Future developments: Multiple geostationary satellite platforms

Exploring "limb effects" and 3D stereo satellite imagery

Bodo Zeschke

Bureau of Meteorology Training Centre
Australian VLab Centre of Excellence

How to access and answer the Socrative Questions

1 On your computer or smartphone open up a new window in your browser type in **b.socrative.com**
Choose "**LOGIN**" (top RHS)
choose "**Student Login**"
Then Room Name
"AOMSUC10"

#1

Socrative question 1: Which of the following apply to you? Please select all that apply

DIT

2

Have

ANSV

A

A. I have examined limb areas of the full disk satellite imagery in the past

B

B. I have not examined limb areas of the full disk satellite imagery

C

C. I do not know about these limb areas of the full disk satellite imagery

D

D. I have examined 3D stereo satellite imagery before

E

E. I have not examined 3D stereo satellite imagery before

F. I do not know about 3D stereo satellite imagery

3

Answer the question

SUBMIT ANSWER

5



You've completed the current activity.
Waiting for the next activity to begin...

4

Finished!

Score: 0/1

Percent: 0%

OK

Socrative question 1: Which of the following apply to you? Please select all that apply

- A. I have examined limb areas of the full disk satellite imagery before
- B. I have not examined limb areas of the full disk satellite imagery
- C. I do not know about these limb areas of the full disk satellite imagery
- D. I have examined 3D stereo satellite imagery before
- E. I have not examined 3D stereo satellite imagery
- F. I do not know about 3D stereo satellite imagery

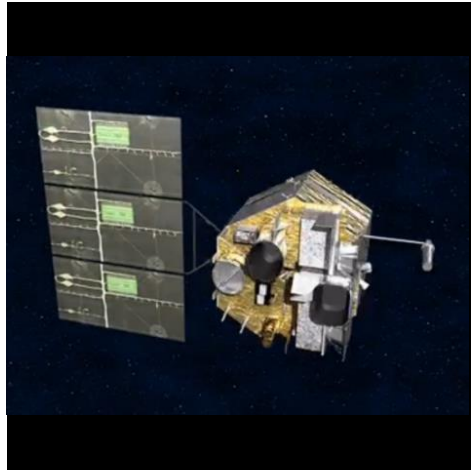
Content of this session

- The constellation of geostationary satellites over our region
- Utilising limb effects for enhanced forecaster monitoring
- Introducing the 3D stereo satellite imagery utilising Himawari-8, Geo-KOMPSAT 2A, GOES-16 and 17 data

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Full earth disk view of the geostationary satellites over the Asia-Oceania (AOMSUC) region



Feng-Yun-4A
(105E)



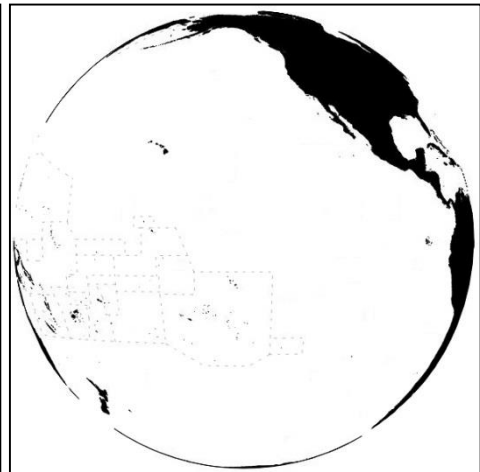
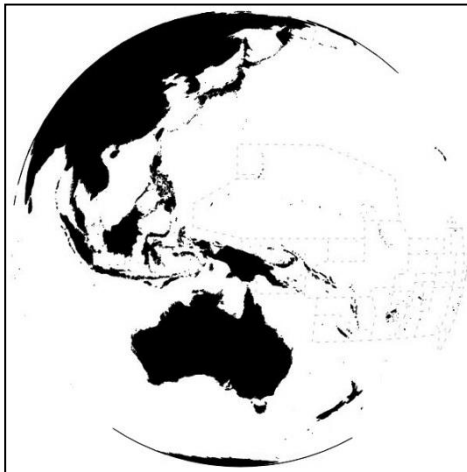
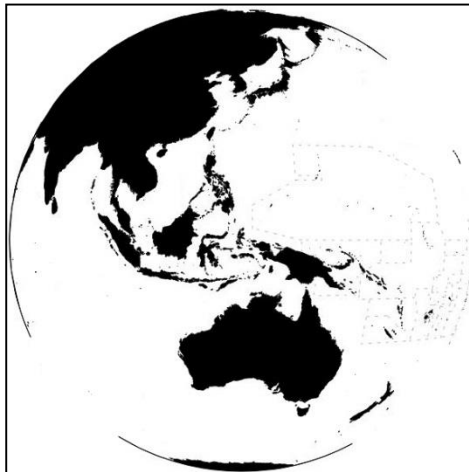
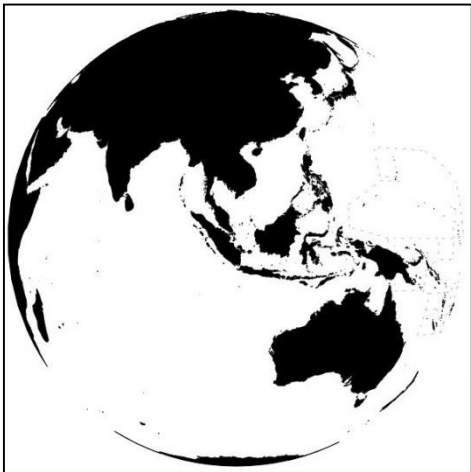
GEO-KOMPSAT-2A
(128.2E)



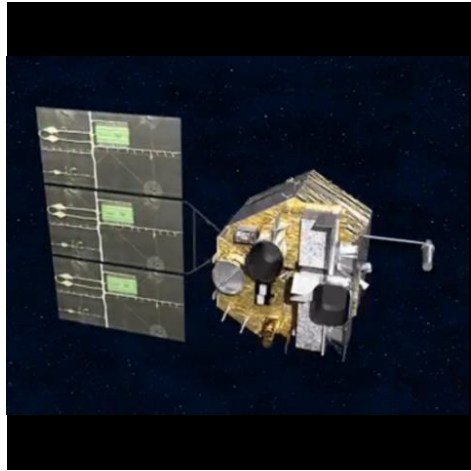
Himawari-8
(140.7E)



GOES-17
(137.2W)



Full earth disk view of the geostationary satellites over our region and "limb regions" as defined by Elmer (2019)



Feng-Yun-4A
(105E)



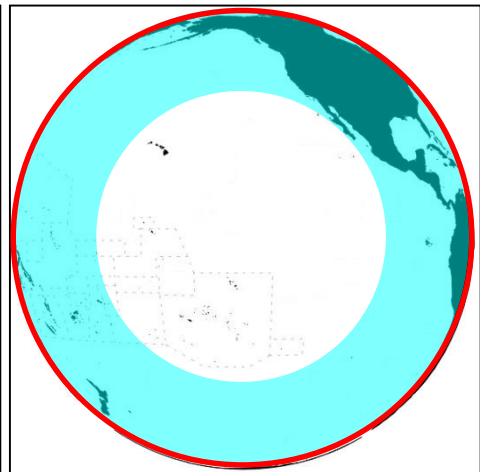
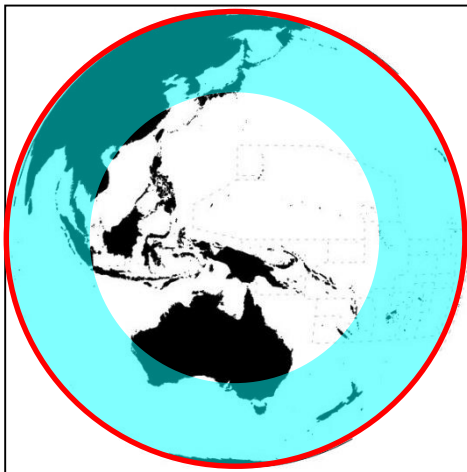
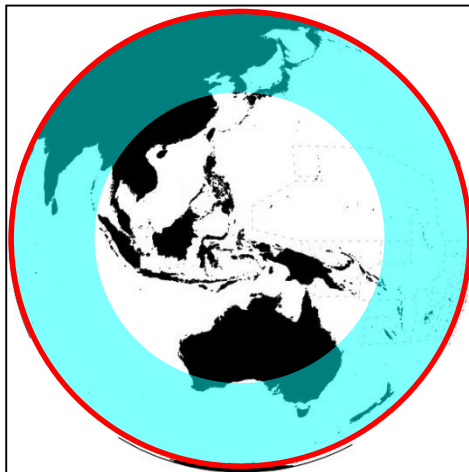
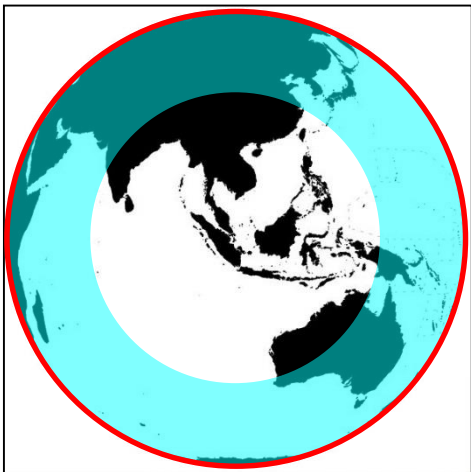
GEO-KOMPSAT-2A
(128.2E)



Himawari-8
(140.7E)



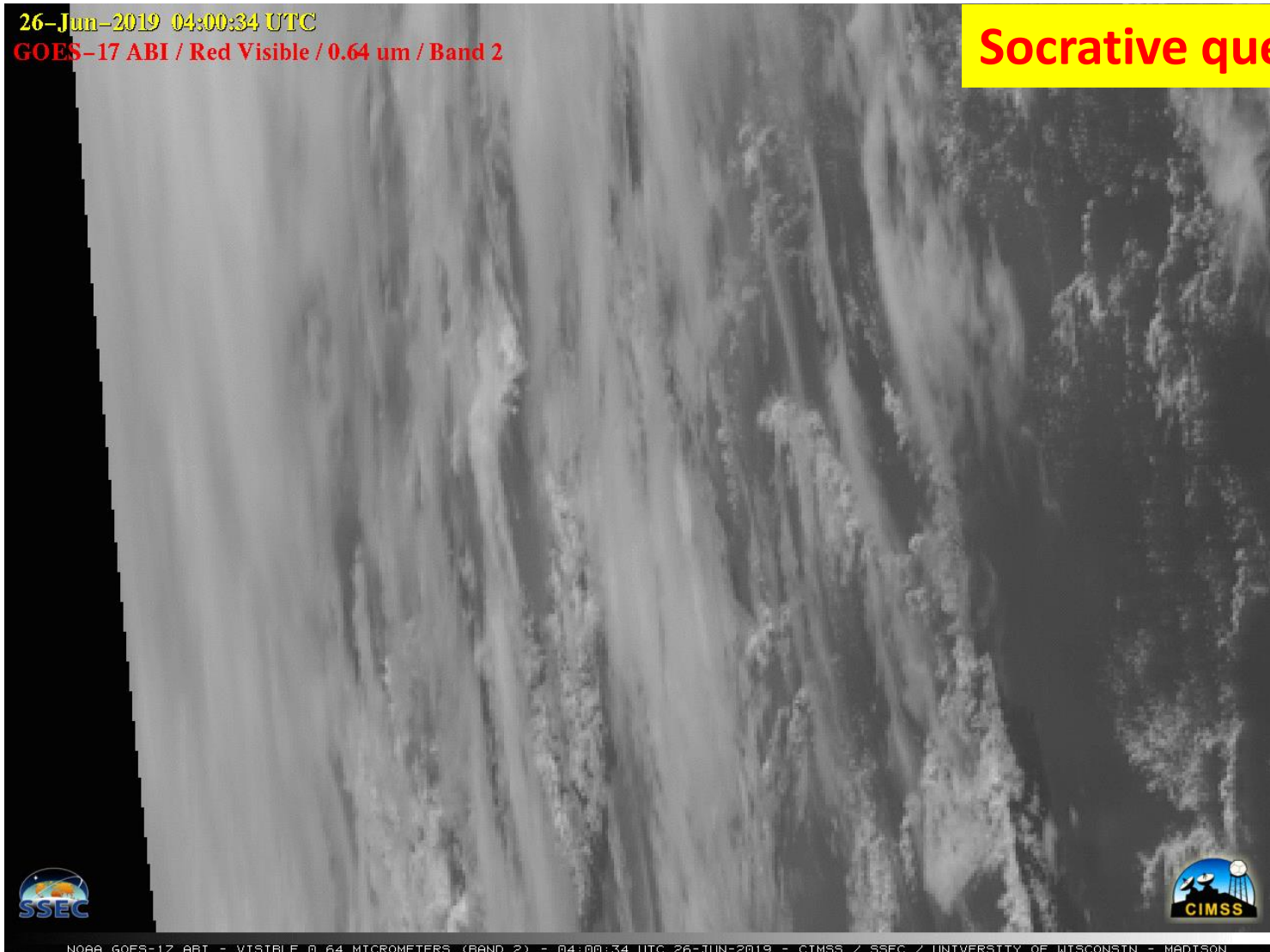
GOES-17
(137.2W)



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Animation 1: The Ulawun eruption (PNG) rendered in the GOES-17 visible (Band 2) data 26th June 2019, Red Visible / 0.64 micron 0400 – 0740UTC

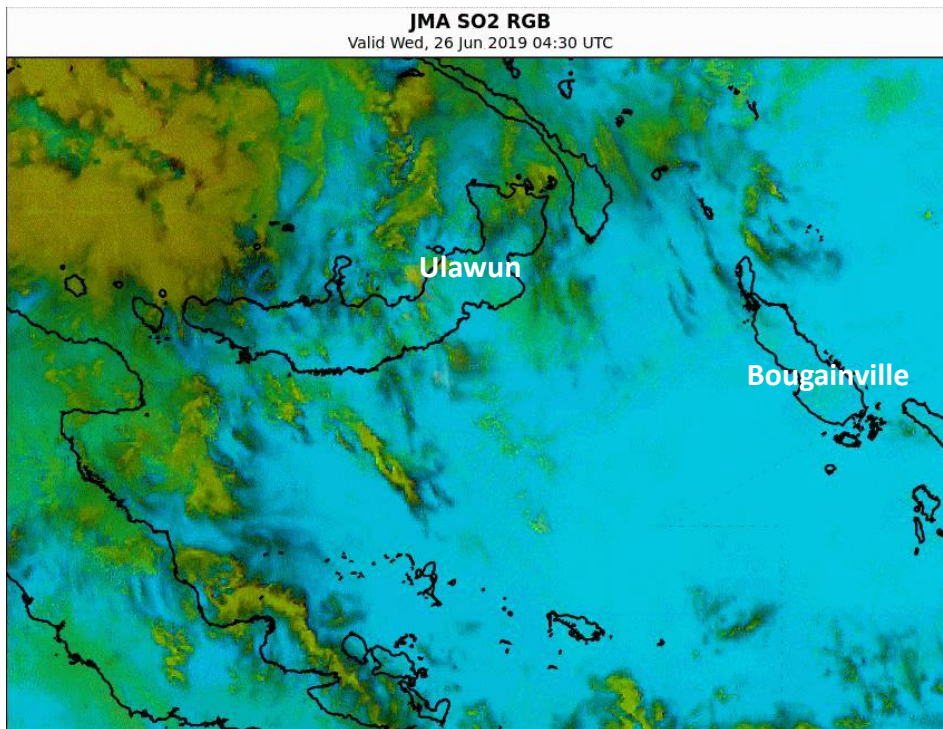


Socratic question 2: What additional information is the earth full disk limb animation giving you?

Write in your answers here.

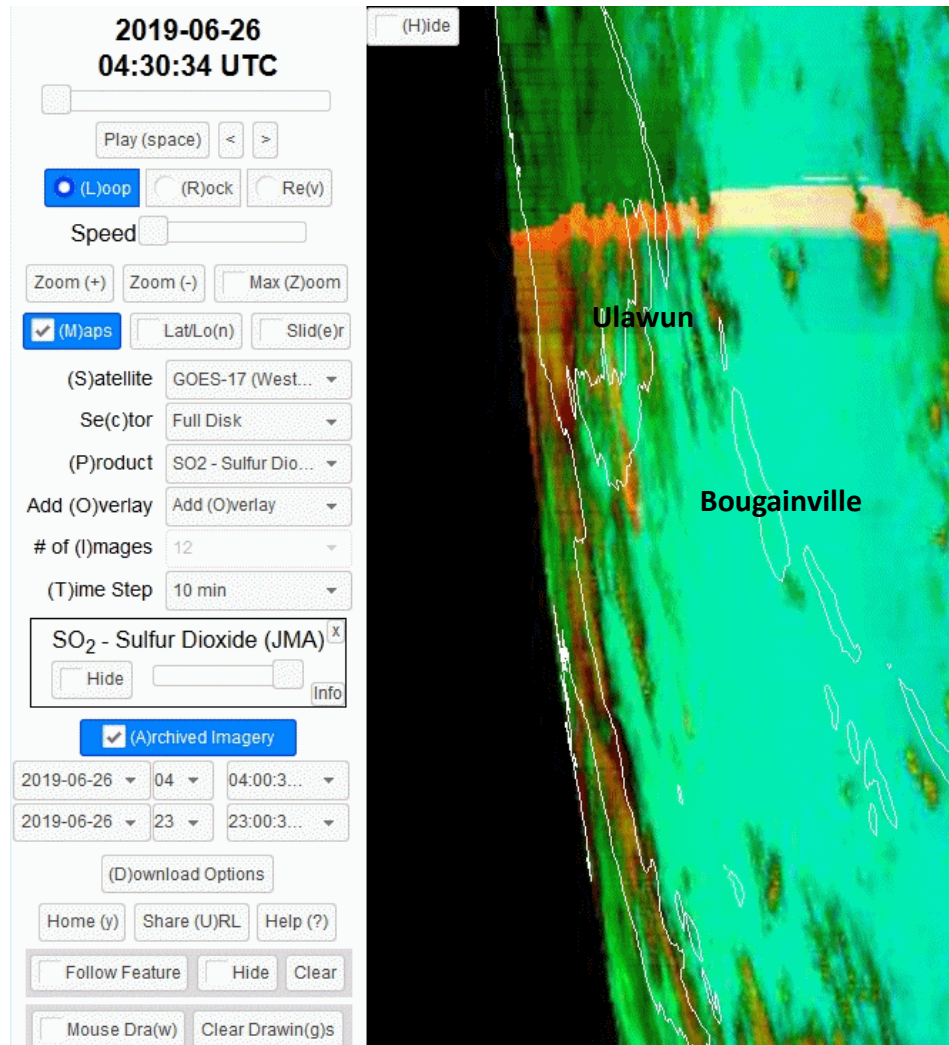
Animation 2: Comparing the JMA SO2 RGB composite utilising Himawari-8 and GOES-17 data: the Ulawun eruption; 0430UTC to 2300UTC 26th June 2019

Please start the Power Point Slide Show to activate the animation



Himawari-8

animation courtesy JMA/BOM

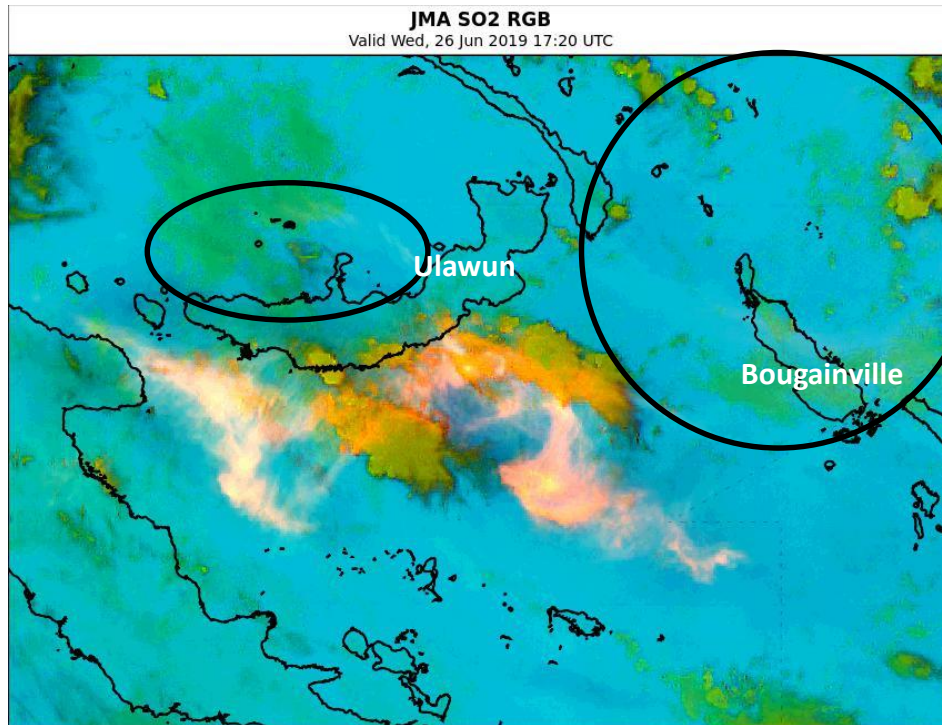


GOES-17

animation courtesy RAMMB/CIRA @ CSU

Comparing the JMA SO2 RGB composite utilising Himawari-8 and GOES-17 data:

the Ulawun eruption;
1720UTC 26th June 2019

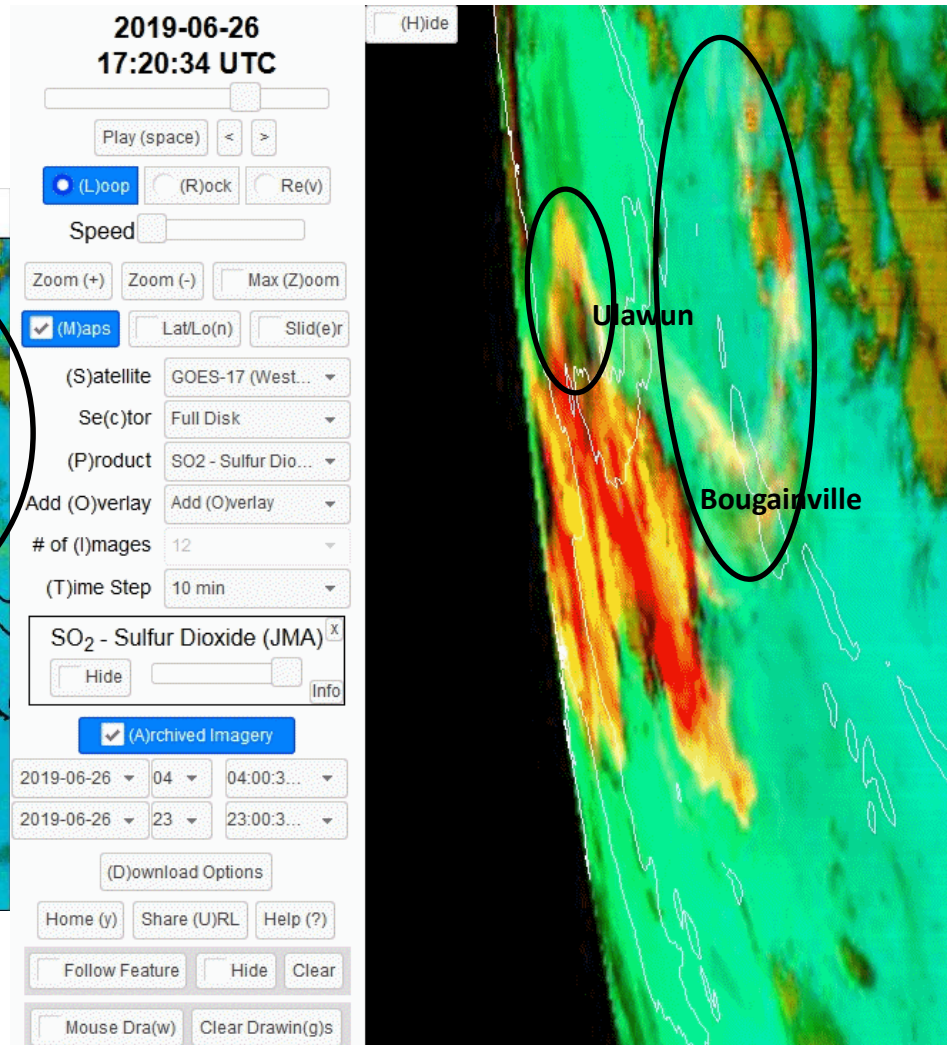


Himawari-8



image courtesy JMA/BOM

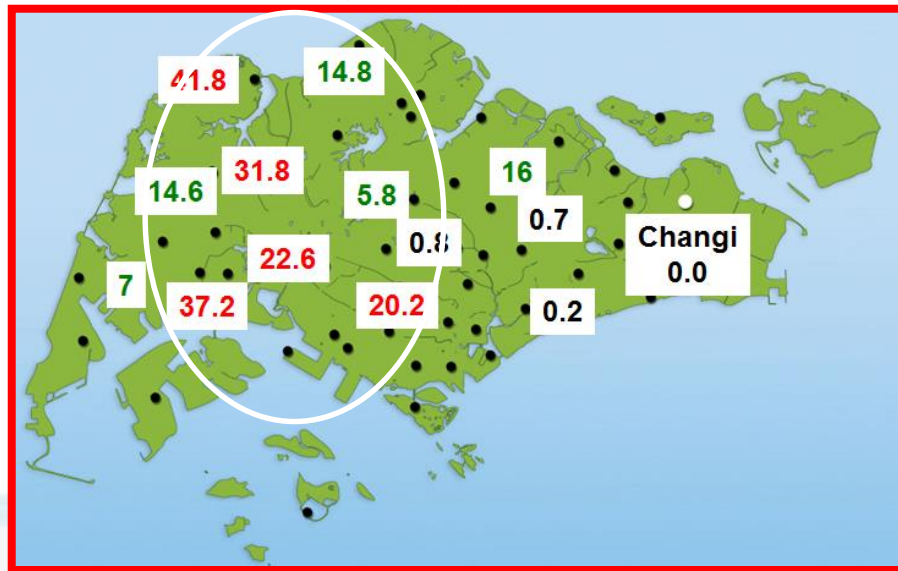
Additional information provided by the GOES-17 satellite due to the limb effect



GOES-17 as displayed in RAMMB/CIRA SLIDER

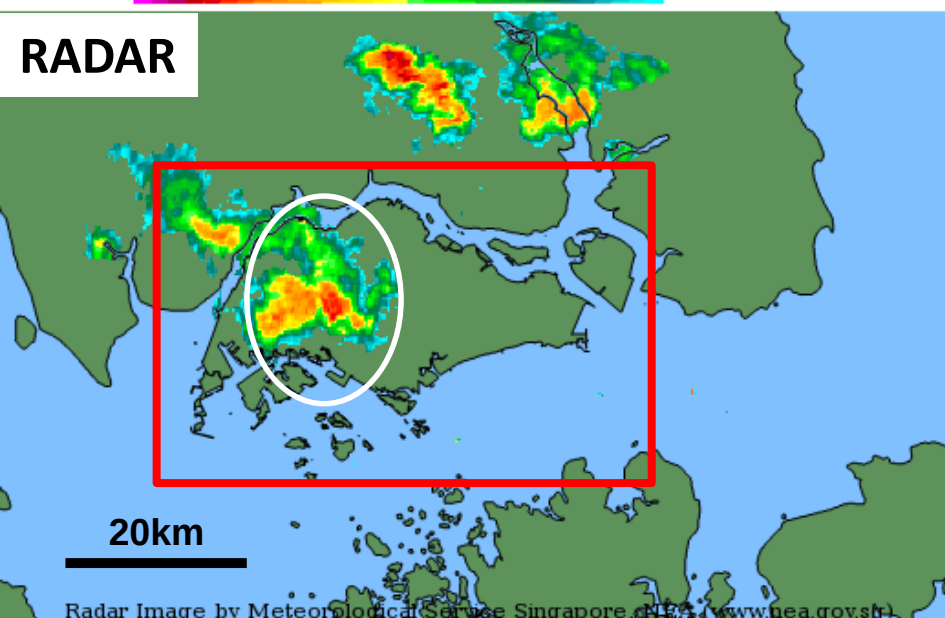
image courtesy RAMMB/CIRA @ CSU

24 hour precipitation (mm)



RADAR and precipitation data courtesy NEA Singapore

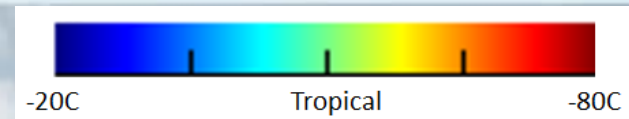
Rain Intensities: Heavy Moderate Light
2017-06-28 16:20 hr



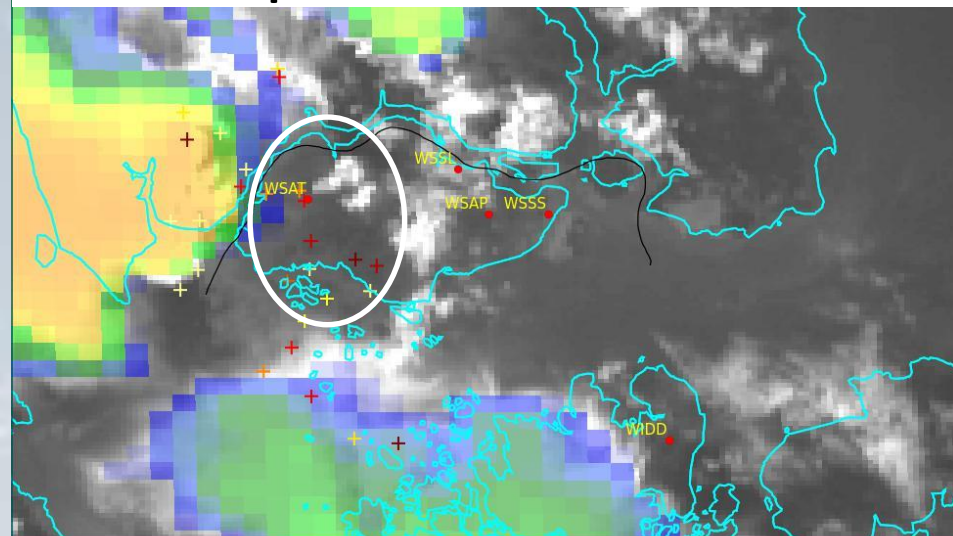
Parallax error issues near the limb

Singapore thunderstorm event,
0810UTC 28th June 2017

Satellite, RADAR and surface
observations



Tropical Sandwich Product



Limb effects in some of the RGB composites

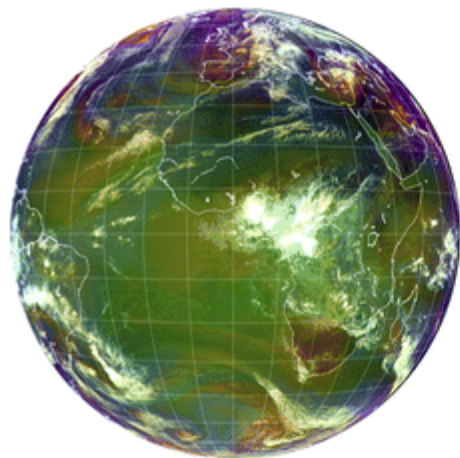
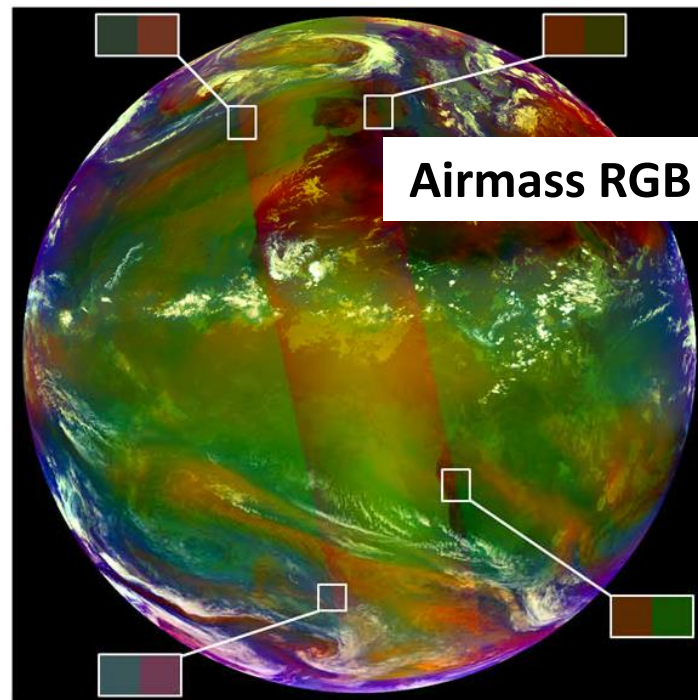
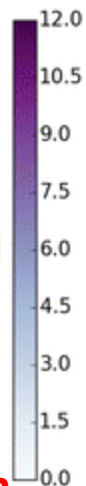


image from Elmer 2019



40° from
Nadir

75° from
Nadir



Airmass RGB

Airmass RGB

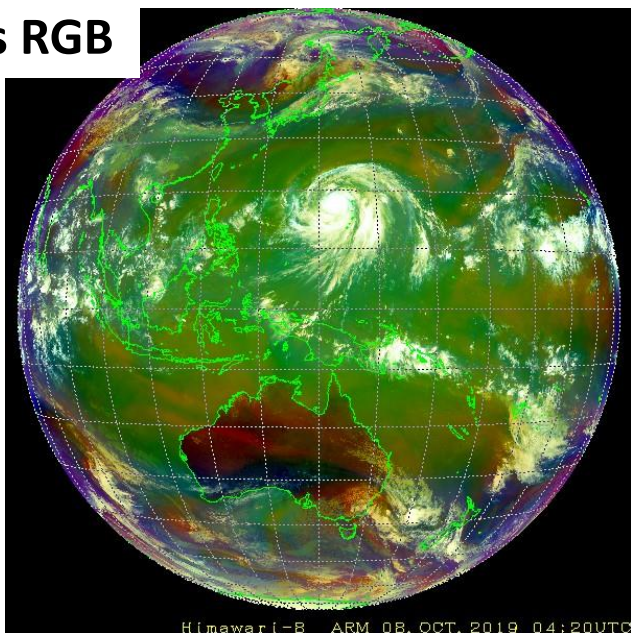


image from JMA

Dust RGB

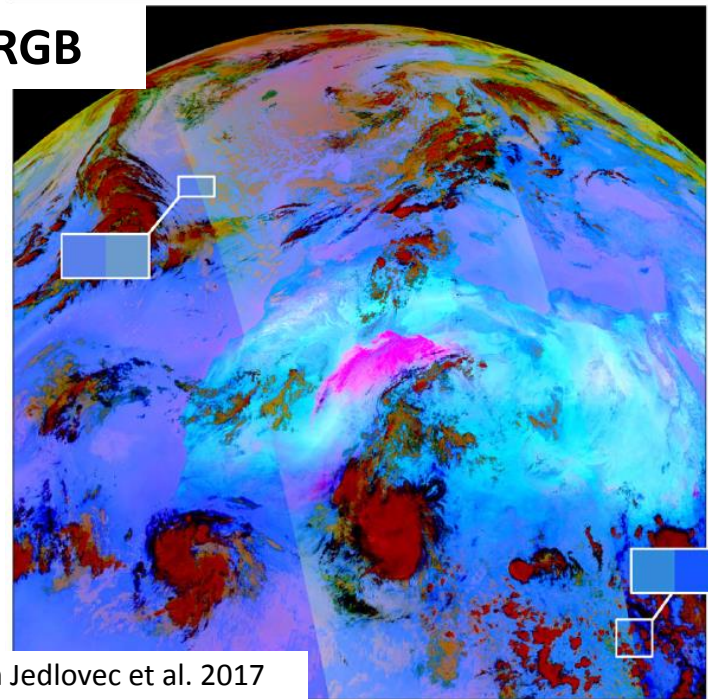


image from Jedlovec et al. 2017

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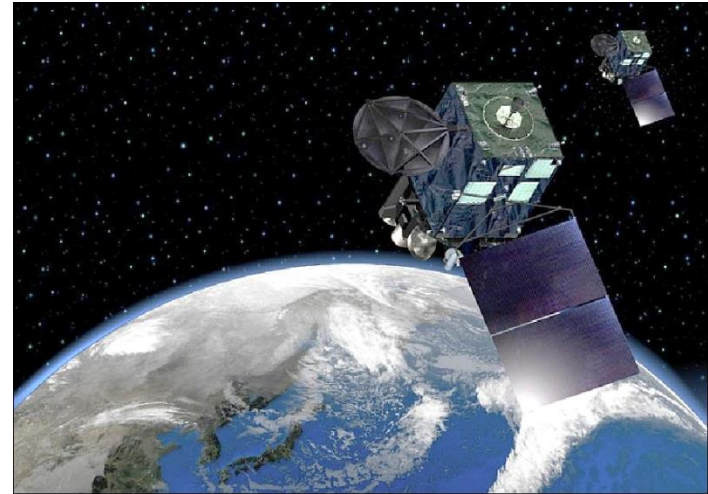
Motivation: utilisation of Himawari-8 and GEO-KOMPSAT-2A data in combination

image from JMA

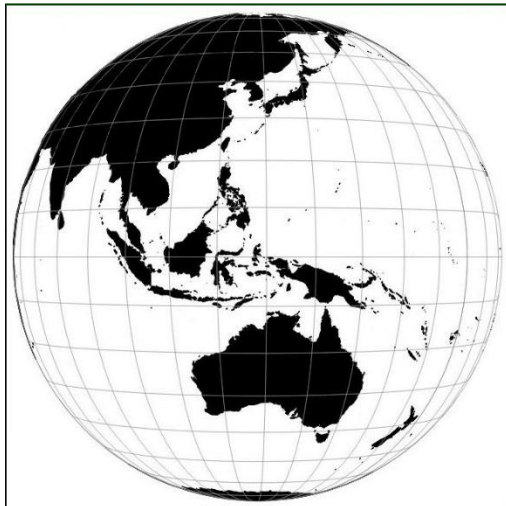
image from KARI



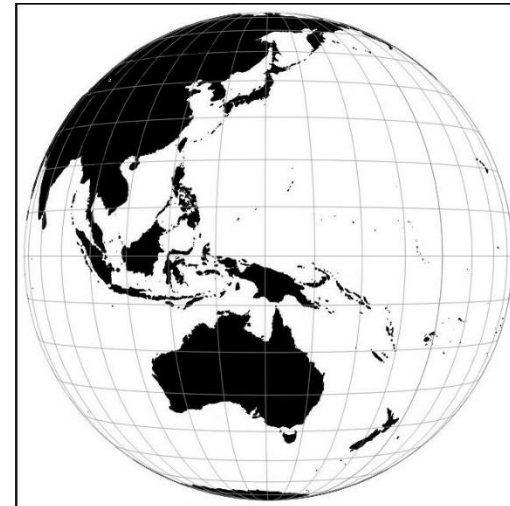
GEO-KOMPSAT-2A located at 128.2E



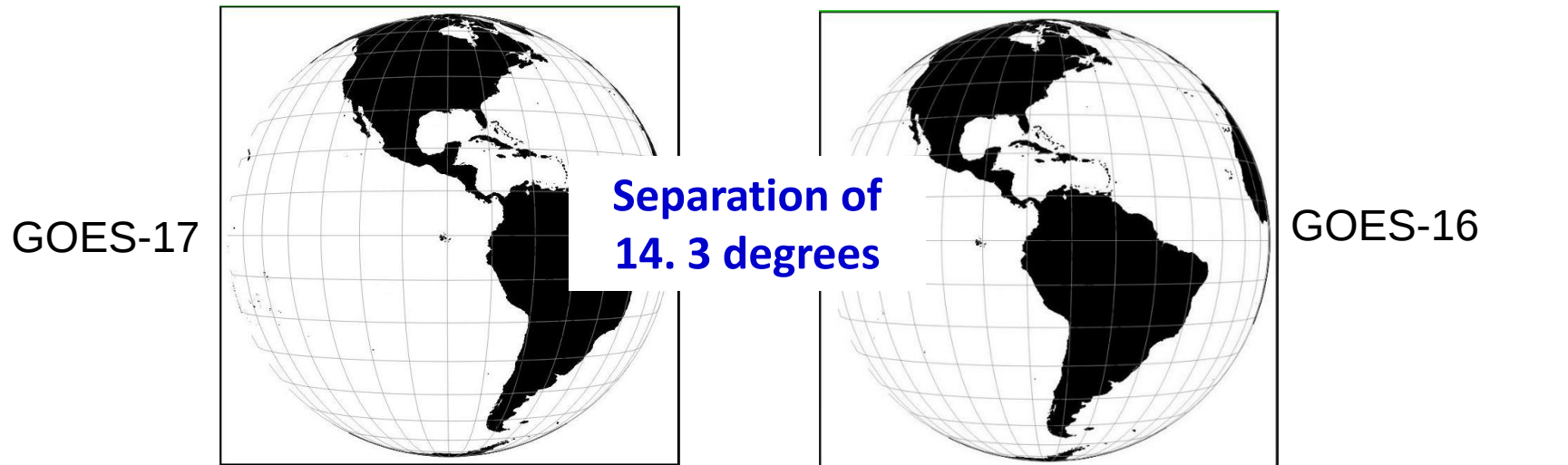
Himawari-8 located at 140.7E,



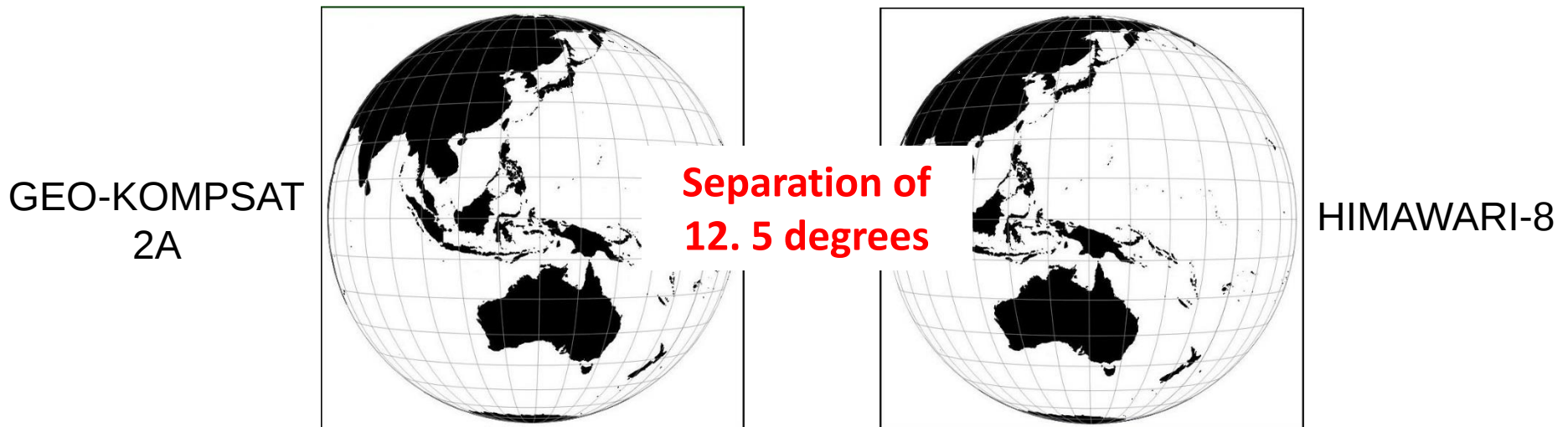
Separation of
12.5 degrees



The Pioneers: GOES-16 / GOES-17 (in check out phase) compared to GEO-KOMPSAT-2A and Himawari-8 separation



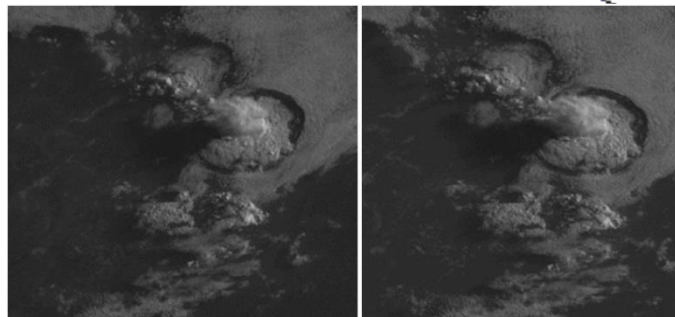
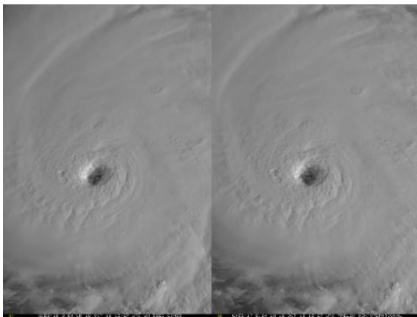
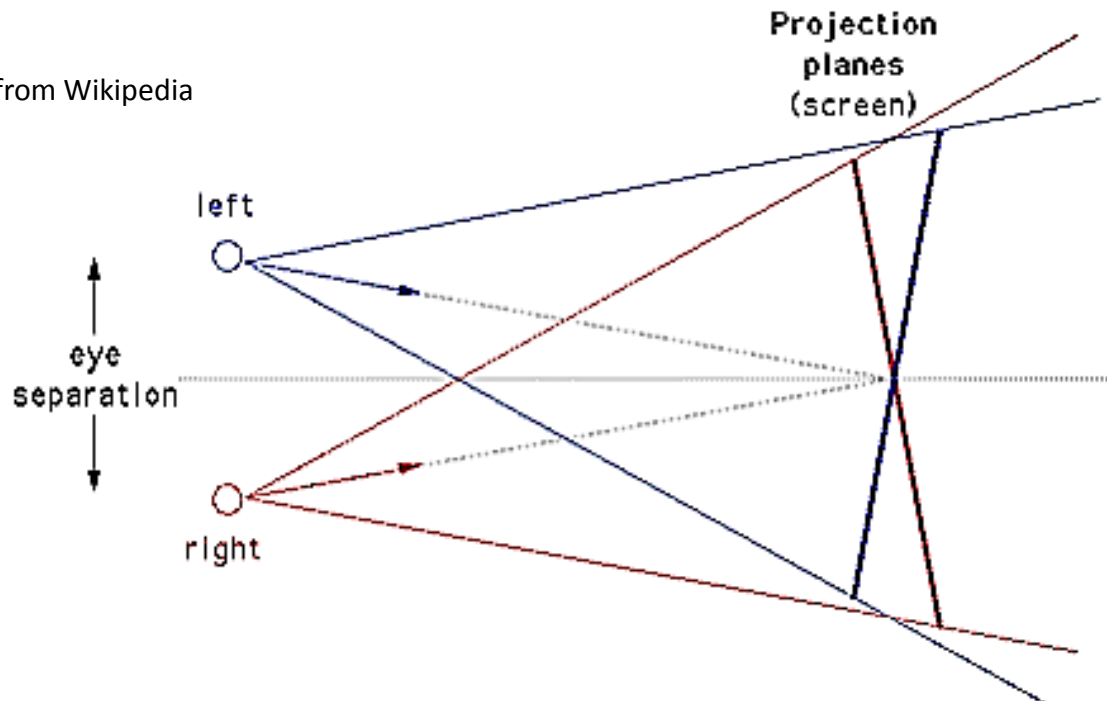
GOES-17 in **test position** at 89.5° W during 2018, GOES-16 at 75.2° W



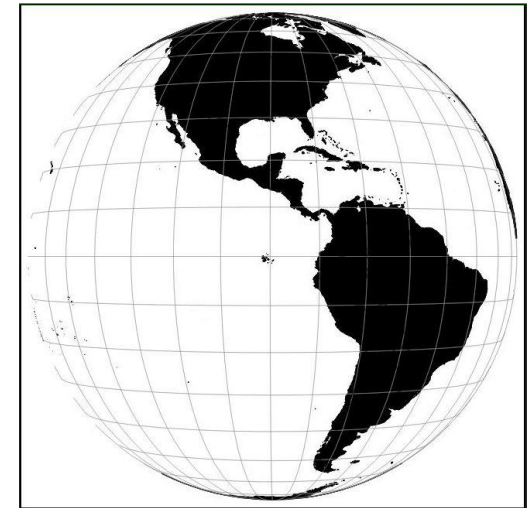
Himawari-8 is located at 140.7E, GEO-KOMPSAT-2A is located at 128.2E

Stereo vision presentation of satellite images – GOES-16 and 17

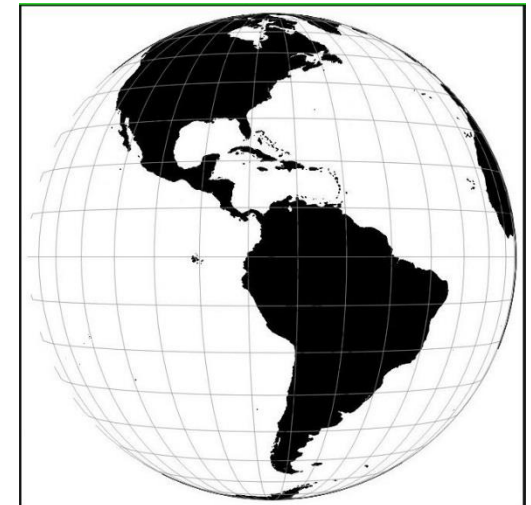
image from Wikipedia



images from CIMSS Satellite Blog, case studies produced by Scott Lindstrom SSEC



GOES-16

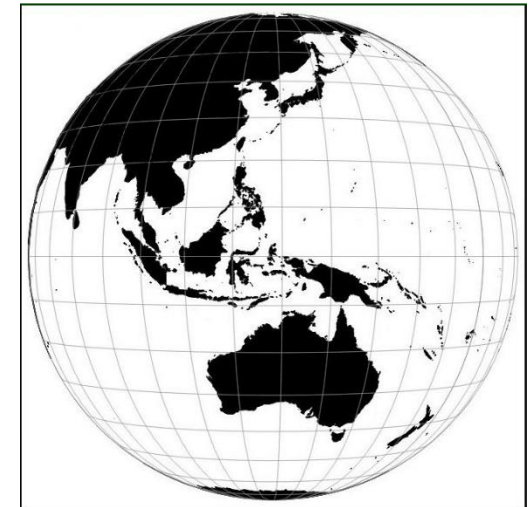
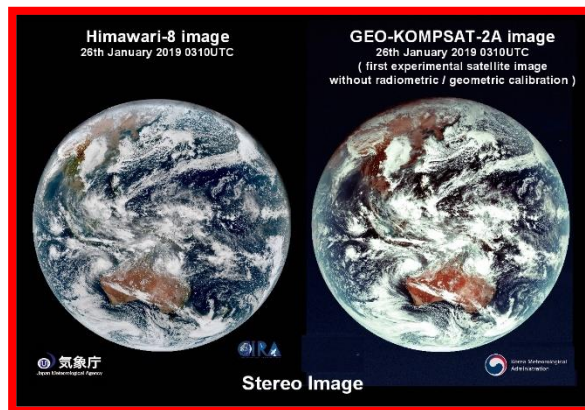
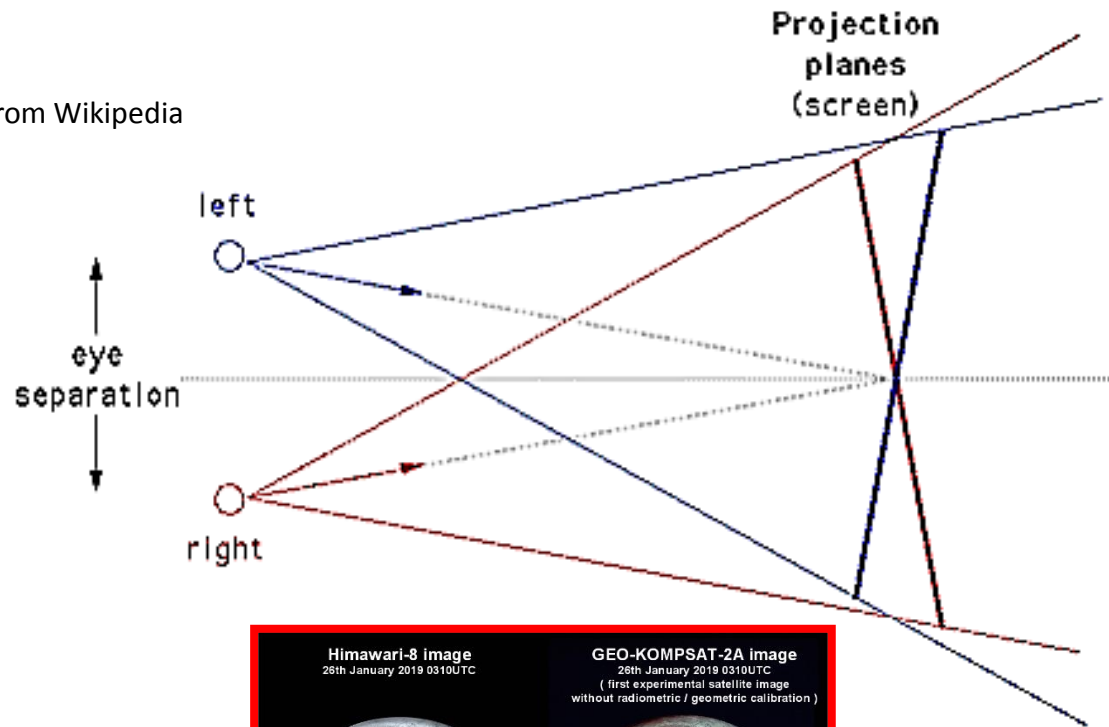


GOES-17

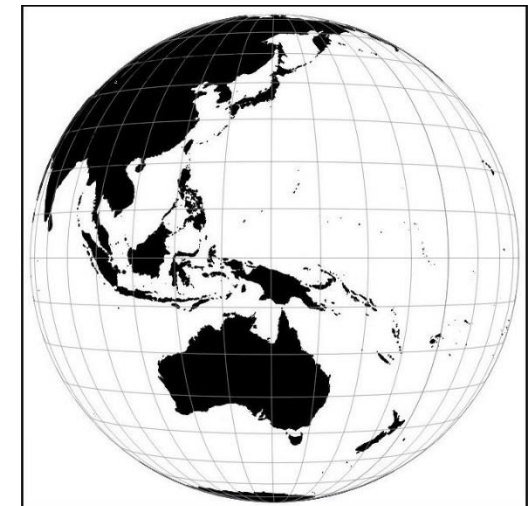
Stereo vision presentation of satellite images

Creating the worlds first GEOKOMPSAT-2A / Himawari-8 stereo image

image from Wikipedia

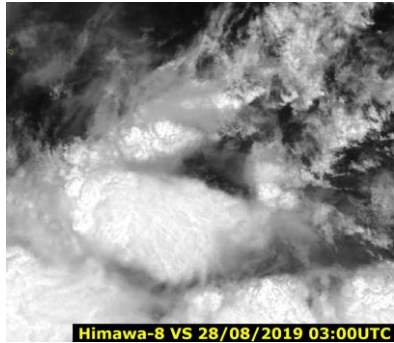


GEOKOMPSAT-2A

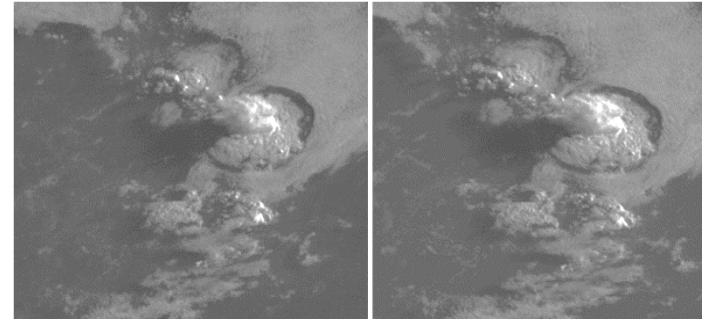


Himawari-8

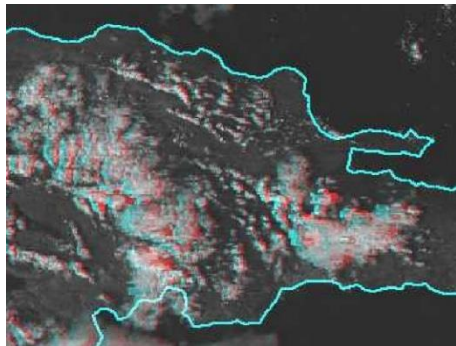
Various ways of presenting 3D stereo satellite imagery



**1: "3D Wiggle"
animation**



2: Stereo pair images
(cross eyed viewing method)



Anaglyph glasses

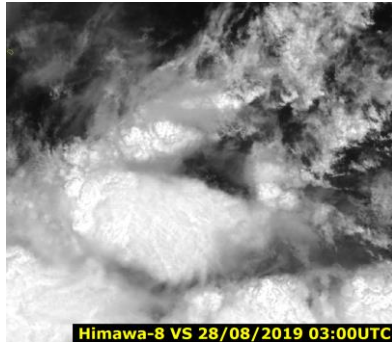


3: "Anaglyph" animation
(requiring viewing glasses)

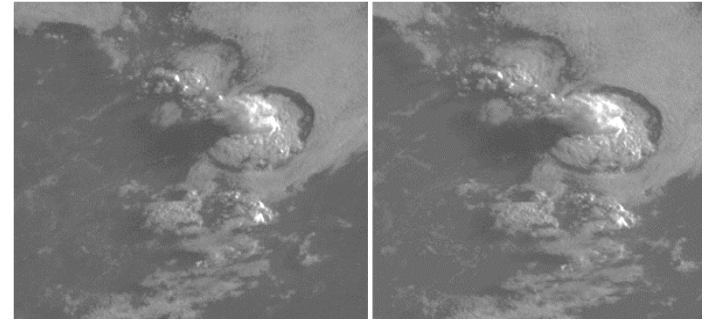


**4: 2 panel image animation
played on Smartphone
and rendered in a viewer**
(eg. Google Cardboard).

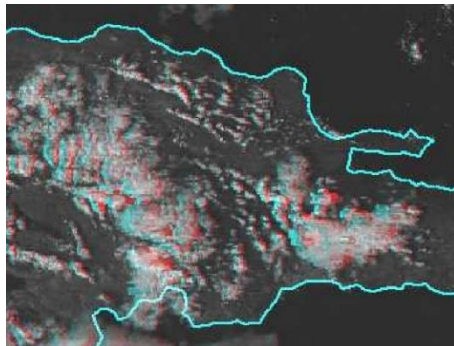
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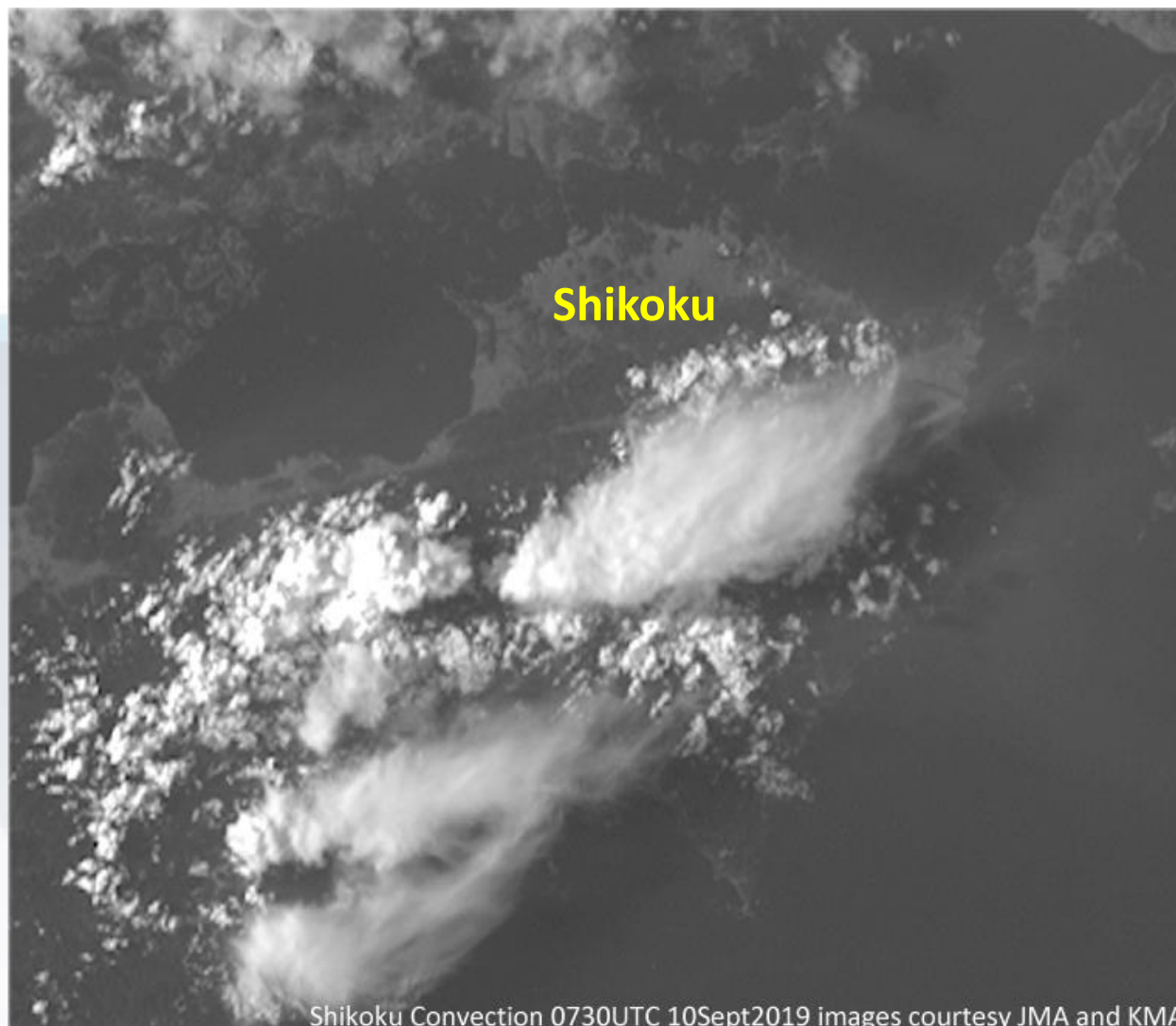


**4: 2 panel image animation
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Animation 3: Demonstrating the stereo effect in GK-2A / H-8 data.

Shikoku thunderstorms, 0730UTC 10th September 2019 (2 frames per second Wiggle 3D animation)

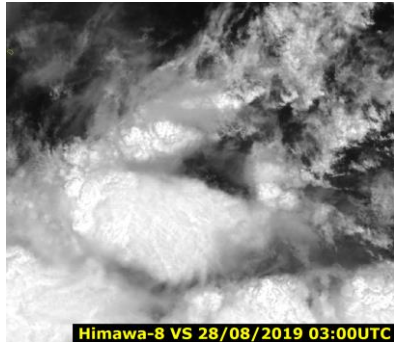
**Please view this
animation
carefully and
desist if it feels
uncomfortable**



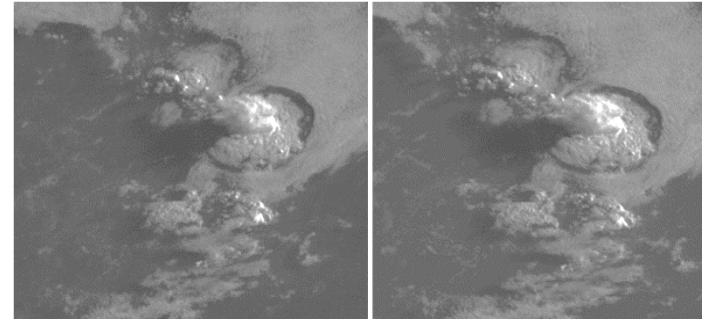
Shikoku Convection 0730UTC 10Sept2019 images courtesy JMA and KMA

Please start the Power Point Slide Show to activate the animation

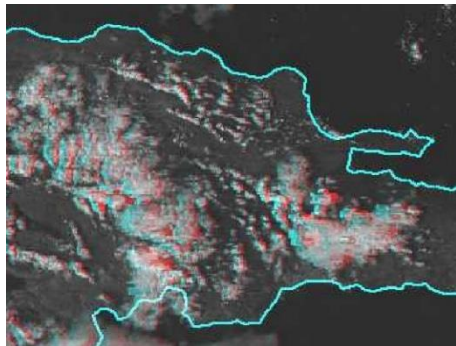
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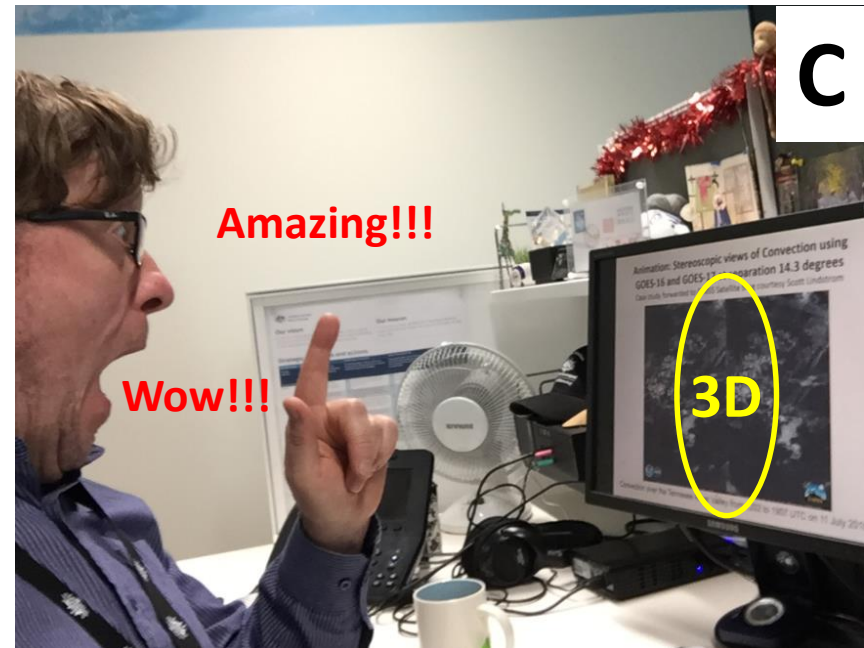
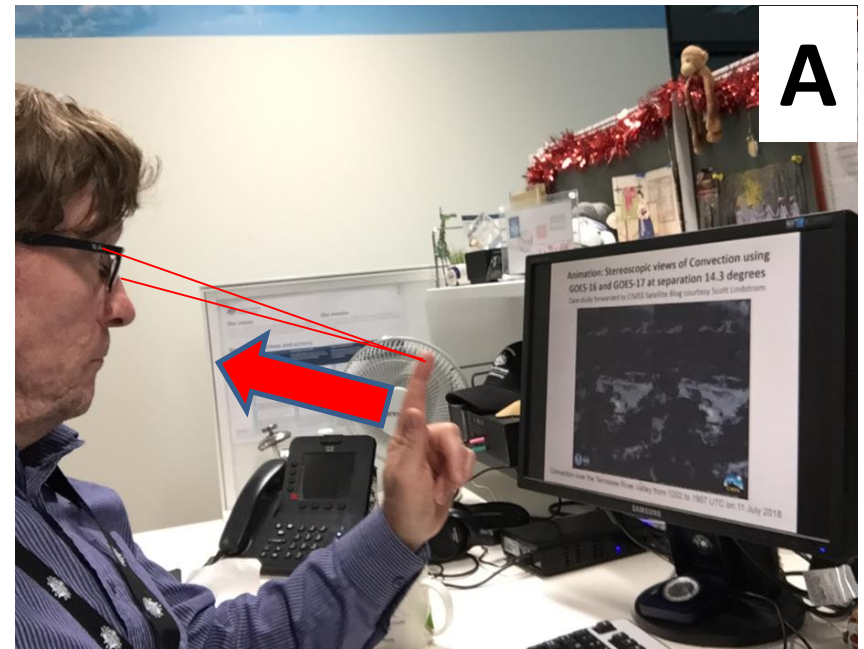


3: "Anaglyph" animation
(requiring viewing glasses)



**4: 2 panel image animation
played on Smartphone
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(eg. Google Cardboard).

How to directly view the 3D two panel animations

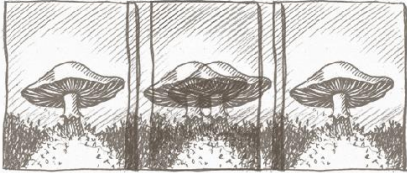


How to view stereo-pairs references

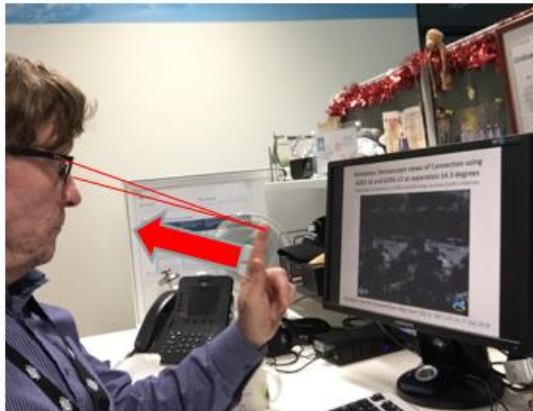
<https://www.kula3d.com/how-to-use-the-cross-eyed-method>

Products Why 3D? Info Shop

LEARN THE CROSS-EYE METHOD



The cross-eyed method can be used on stereoscopic pictures where the left image is on the right side and vice versa. It requires no 3D glasses or gear, only the desire to learn. This is one way to do it:



<http://www.starosta.com/3dshowcase/ihelp.html>

BORIS STAROSTA *Stereoscopic Art & 3-D Photography*

Help: How to Free-View the Stereo Pairs

Each stereo view consists of two images, one for each eye. Free viewing is the technique that will allow you to direct each of these images separately and simultaneously into each eye. Once that happens, you are said to have "fused" the pair of images into a stereo view.

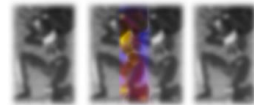
At the bottom of this page a stereo pair of images is loading with which you can practice. All the stereo pairs shown on this site are in the "cross-eyed" format (my apologies to all the "wall-eyed" people). That means that the first (leftmost) image is for your right eye and the right image is for your left eye. Looking at the pair in a natural, relaxed manner, what you see will be similar to this:



Now cross your eyes, so that the pair of images will double to four, and be somewhat out of focus:



Next, slowly uncross your eyes, and observe with your mind what is happening to the images. At some point, the two pairs of images you are seeing will begin to overlap:



Socrative question 3

The worlds first GEO-KOMPSAT-2A / Himawari-8 stereo image!

joint effort between Dr Hyesook Park (KMA), Bodo Zeschke (BMTC) and Akihiro Shimizu (JMA)

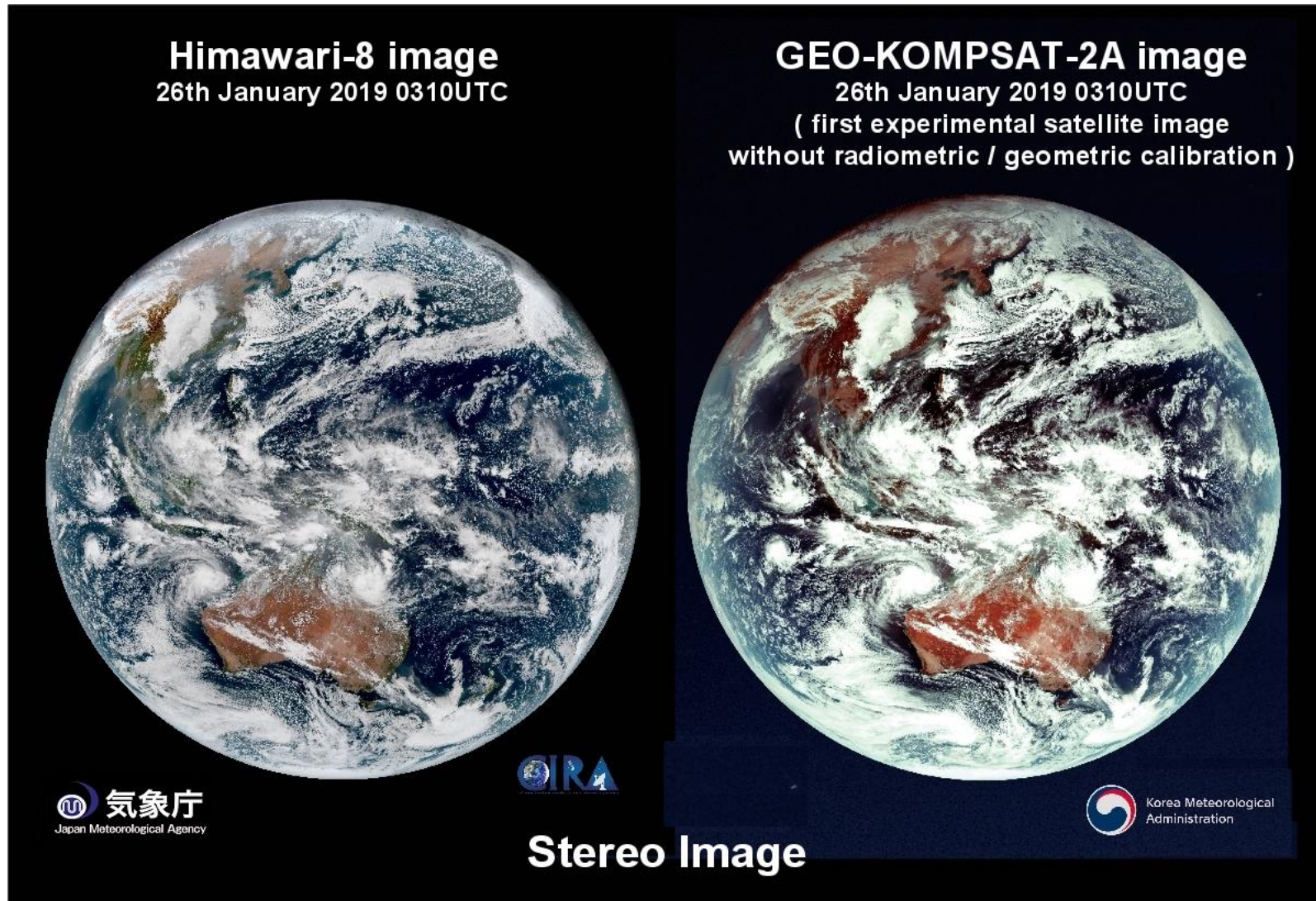


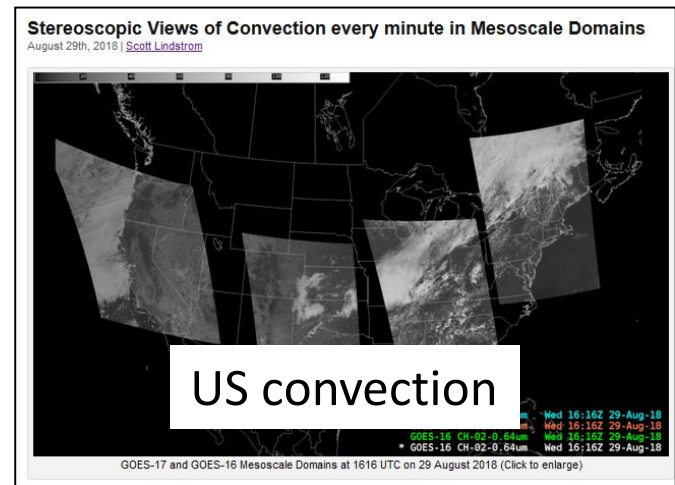
image pair courtesy Bodo Zeschke, Australian Bureau of Meteorology ; Himawari image courtesy JMA ; GK2A image courtesy KMA and Dr. Hyesook Park. [GEOKOMPSAT-2A is also known as Chollian-2a](#)

Socratic question 3: Can you see the "round" earth using the cross-eyed method?

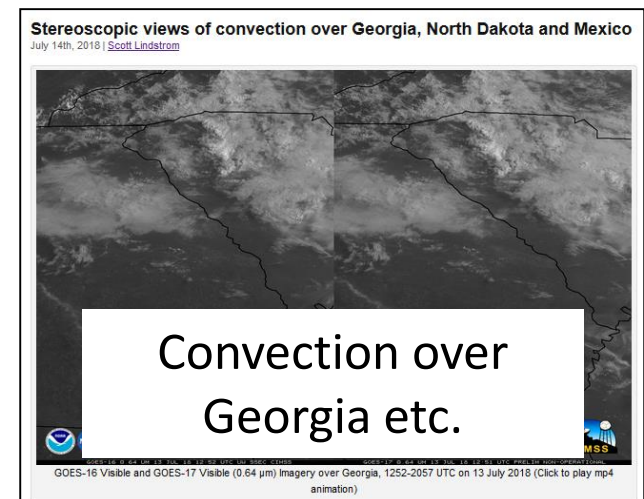
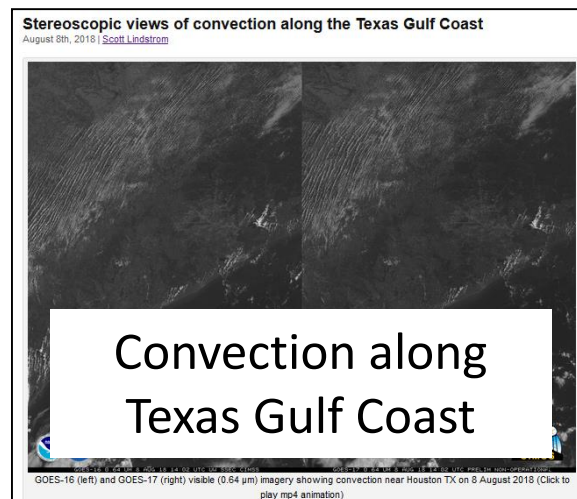
- A. Yes I can. It shows the 3D stereo effect well
- B. Yes I can. But I cannot see the 3D stereo effect very well.
- C. It is so-so (ok).
- D. No I cannot.
- E. No I cannot. It is uncomfortable to look at.

Some additional 3D case studies on the CIMSS Satellite Blog web site utilising GOES-16 / GOES-17 imagery.

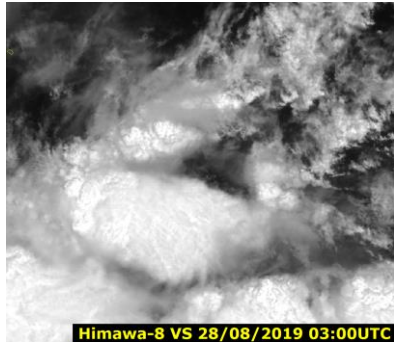
Case studies forwarded to CIMSS Satellite Blog courtesy Scott Lindstrom



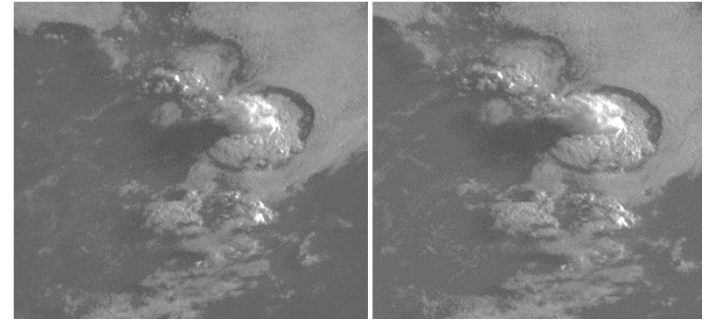
<https://cimss.ssec.wisc.edu/goes/blog/?s=stereo>



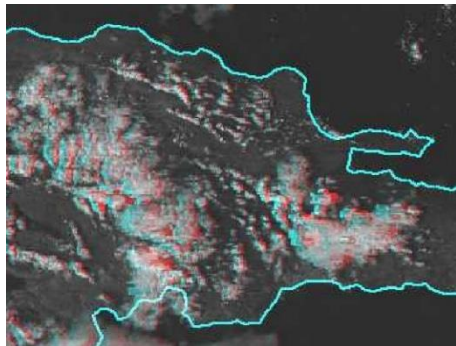
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Anaglyph glasses

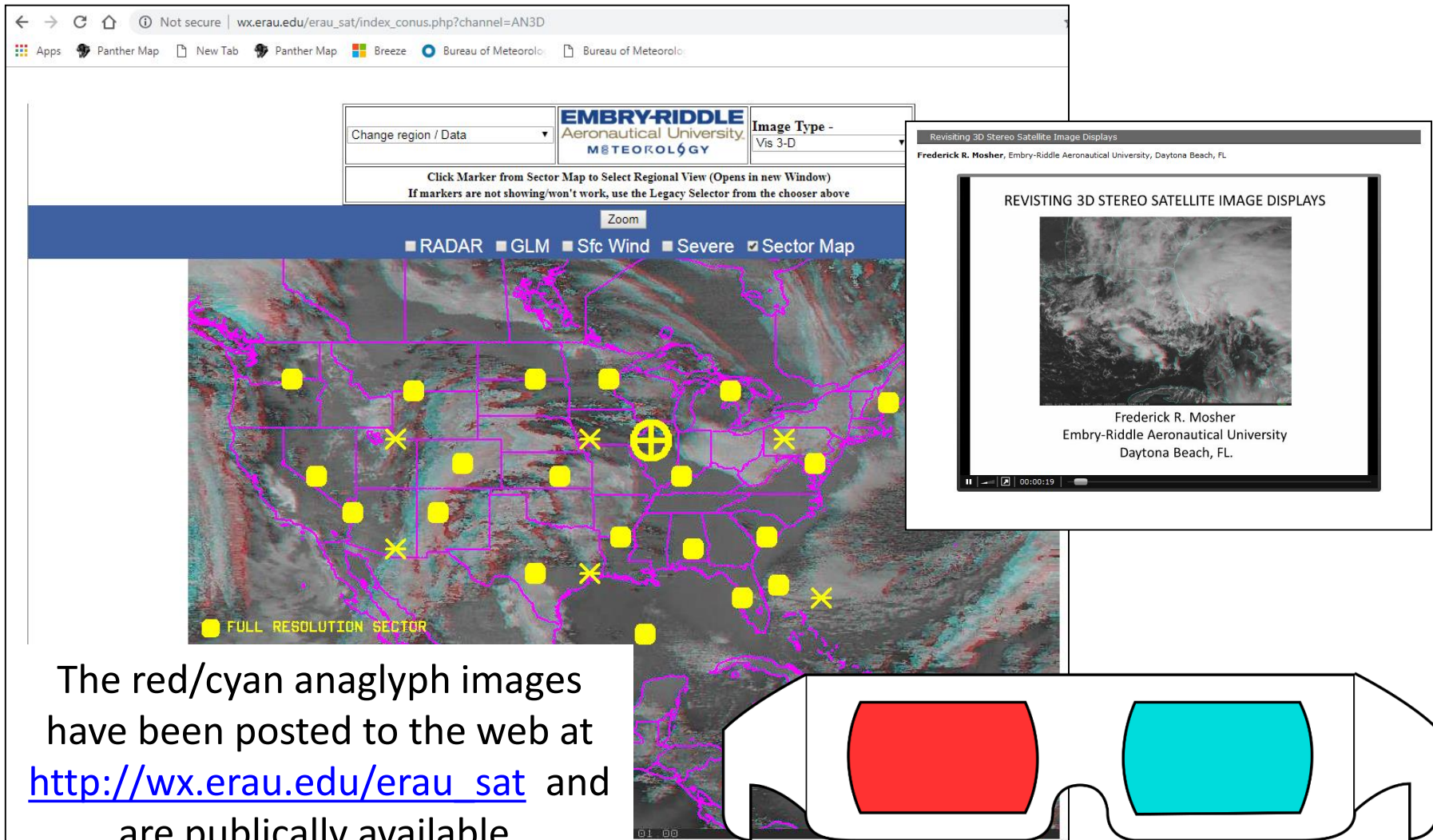


3: "Anaglyph" animation
(requiring viewing glasses)



**4: 2 panel image animation
played on Smartphone
and rendered in a viewer**
(eg. Google Cardboard).

An online source of 3D "anaglyph" images over the CONUS domain, from Embry-Riddle Aeronautical University website

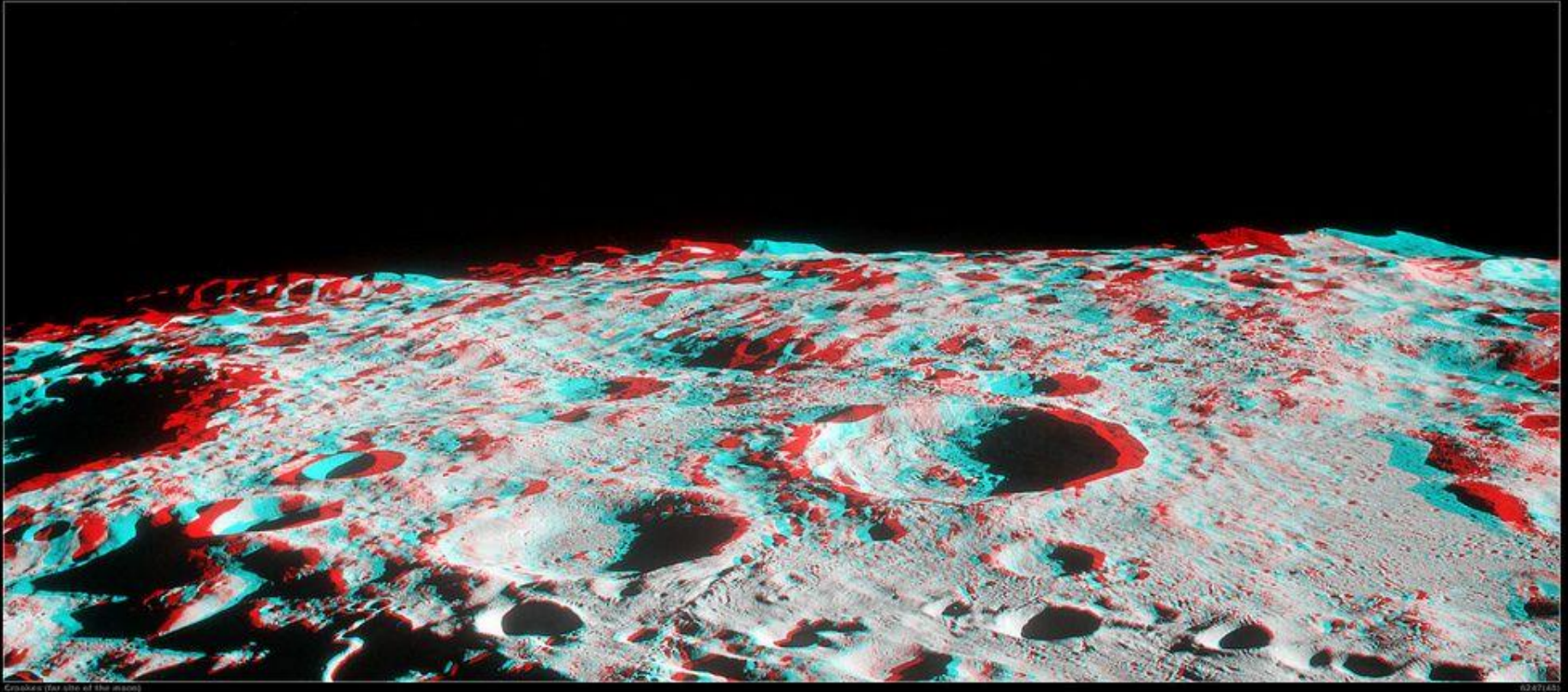


The screenshot displays a web browser window with the URL wx.erau.edu/erau_sat/index_conus.php?channel=AN3D. The page features a map of the contiguous United States (CONUS) with a red/cyan anaglyph overlay. The map is divided into sectors, with yellow squares indicating 'FULL RESOLUTION SECTOR' and yellow 'X' marks indicating other sectors. A legend at the bottom left of the map area shows a yellow square next to the text 'FULL RESOLUTION SECTOR'. The website header includes the Embry-Riddle Aeronautical University Meteorology logo and a navigation bar with options like 'RADAR', 'GLM', 'Sfc Wind', 'Severe', and 'Sector Map'. A video player overlay on the right side of the map displays the title 'REVISING 3D STEREO SATELLITE IMAGE DISPLAYS' and the name 'Frederick R. Mosher, Embry-Riddle Aeronautical University, Daytona Beach, FL'. The video player shows a 3D anaglyph image of a satellite view of the Earth. Below the video player, a pair of 3D glasses is shown, with the left lens colored red and the right lens colored cyan, indicating the anaglyph format.

The red/cyan anaglyph images have been posted to the web at http://wx.erau.edu/erau_sat and are publically available.

A good example of an Anaglyph image

(the moon's limb as taken from Apollo 11)

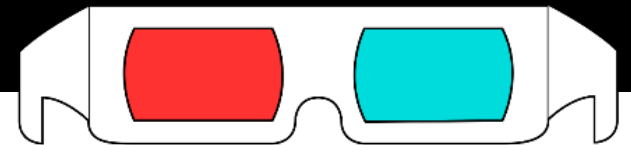


Crosses (far side of the moon)

6/47(45)

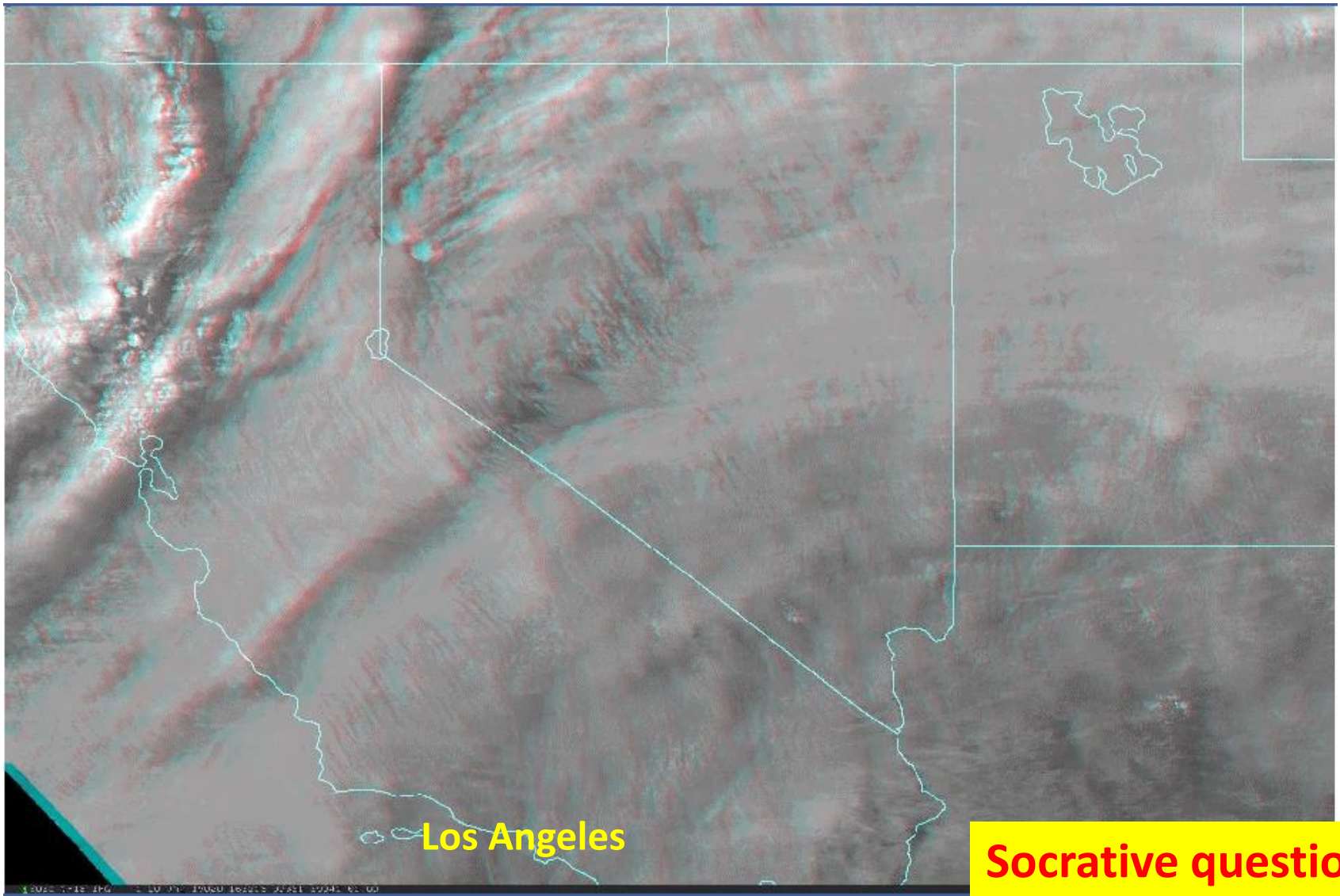
APOLLO - 11

Moon by Patrick Vantuya



Animation 4: Clouds clearing over Nevada, USA

January 2019 (5FPS rocking animation)



Socratic question 4: Can you see the 3 dimensional effect of this example using the anaglyph glasses?

- A. Yes I can. It shows the 3D stereo effect well
- B. Yes I can. But I cannot see the 3D stereo effect very well.
- C. It is so-so (ok).
- D. No I cannot.
- E. No I cannot. It is uncomfortable to look at.

Animation 5: Low over the central United States of America

2002UTC 13th March to 0002UTC 14th March 2019 anaglyph images (5 FPS animation)

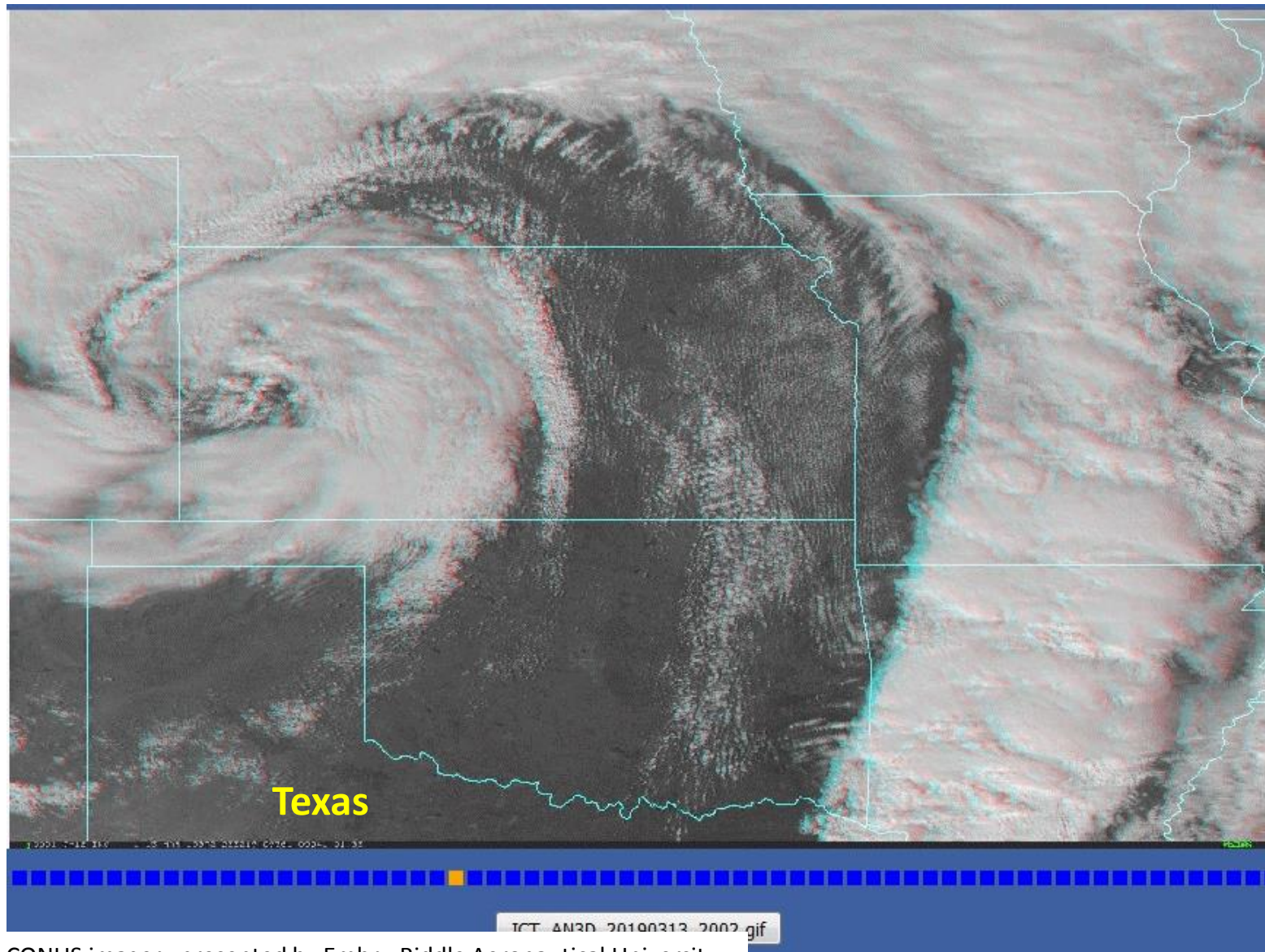
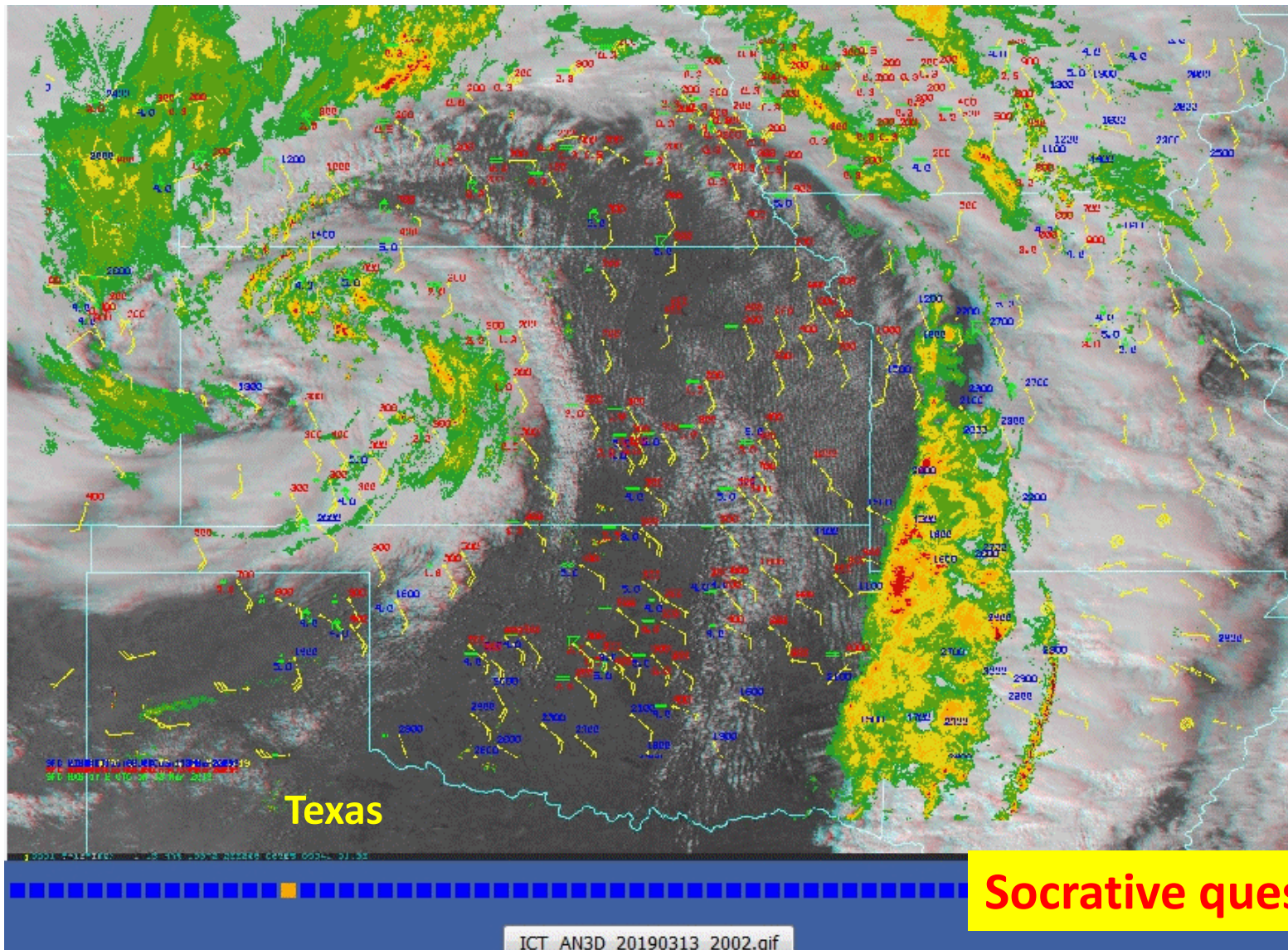


image from CONUS imagery presented by Embry-Riddle Aeronautical University

Animation 6: Superposition of RADAR and surface observations on 3D anaglyph satellite data (5 FPS animation)



Socrative question 5

Socrative question 5: How well do the anaglyph 3D satellite, RADAR and surface observations render the 3D stereo effect?

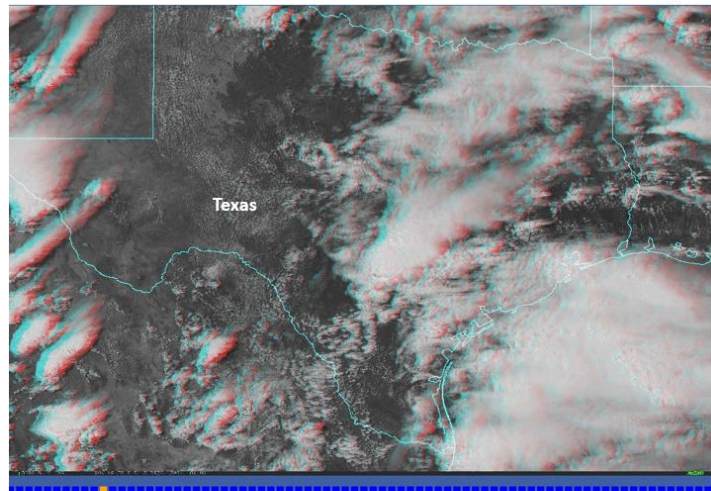
- A. The superposition of the observational data enhances the 3D stereo effect
- B. The superposition of the observational data substantially reduces the 3D stereo effect.
- C. There is no difference between the two animations.
- D. I cannot see the 3D stereo effect in either animation

Some additional anaglyph 3D case studies for you to examine with your anaglyph glasses

<http://www.virtuallab.bom.gov.au/events/aomsuc-training/aomsuc-10-training-event-presentations-and-resources/>

Please start the Power Point Slide Show to activate the animation

Animation: Texas Convection anaglyph imagery 
2101UTC 4th June to 0301UTC 5th June 2019 (5frames per second) image from Wikipedia



AUS_AK00_20190604_2101.gif

by Embry-Riddle Aeronautical University

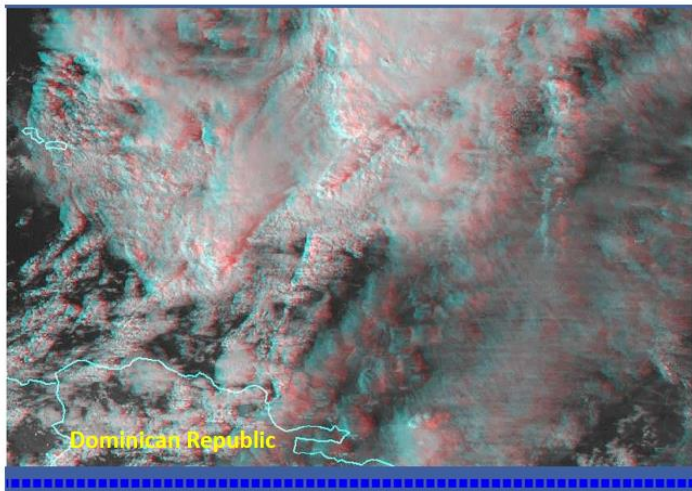
Additional Anaglyph Animation 1

Additional Anaglyph Animation 2

Additional Anaglyph Animation 3

Please start the Power Point Slide Show to activate the animation

Animation: Thunderstorms north of Puerto Rico
2002UTC 15th February to 0047UTC 16th February 2019
(5FPS rocking animation, visible to enhanced infrared transition) image from Wikipedia



Dominican Republic

image from CONUS imagery presented by Embry-Riddle Aeronautical University

Please start the Power Point Slide Show to activate the animation

Animation: Thunderstorms off of Mexico
2242UTC 23rd January 2019
(5FPS rocking animation, visible to enhanced infrared transition) image from Wikipedia

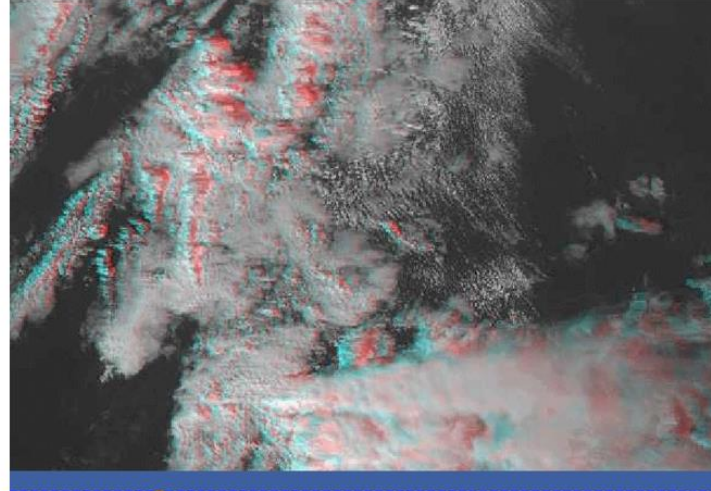
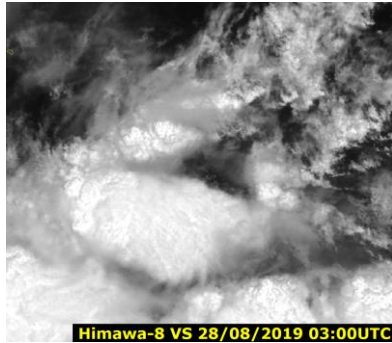
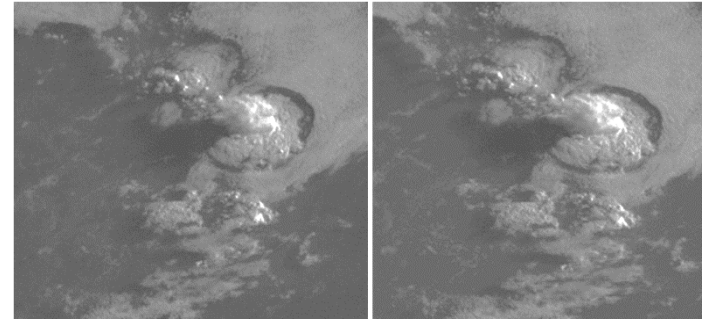


image from CONUS imagery presented by Embry-Riddle Aeronautical University

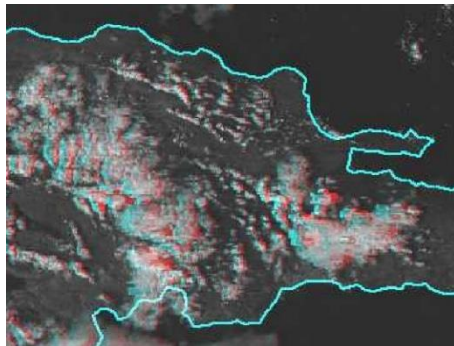
Various ways of presenting 3D stereo satellite imagery



**1: "3D Wiggle"
animation**



2: Stereo pair images
(cross eyed viewing method)



Anaglyph glasses



3: "Anaglyph" animation
(requiring viewing glasses)



**4: 2 panel image animation
played on Smartphone
and rendered in a viewer**
(eg. Google Cardboard).

image from Google Earth



**Method 4
analogy:
Virtual Reality
exercise**

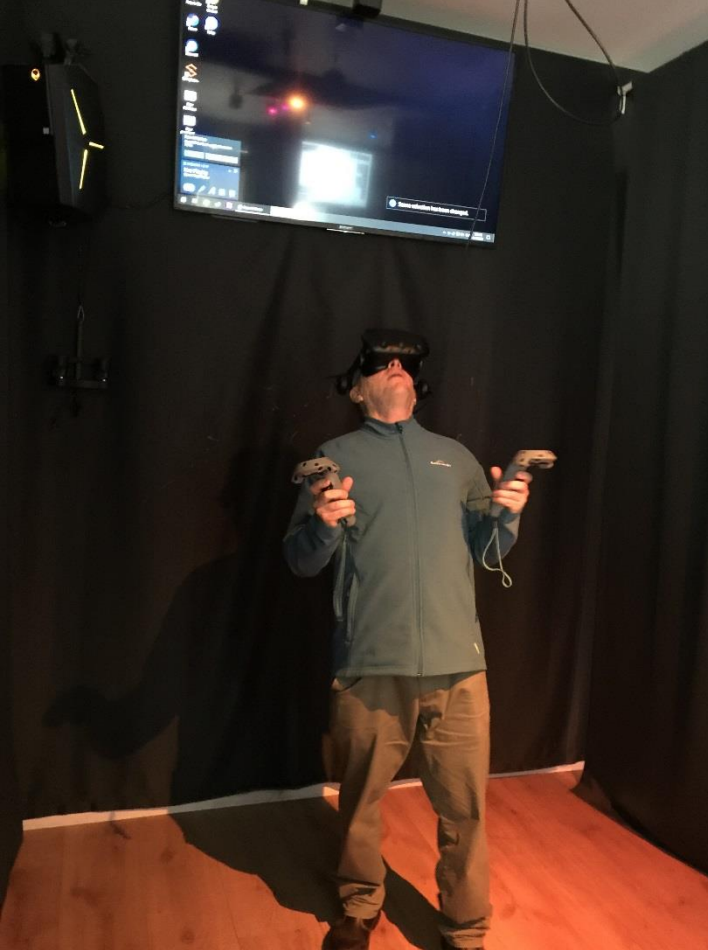
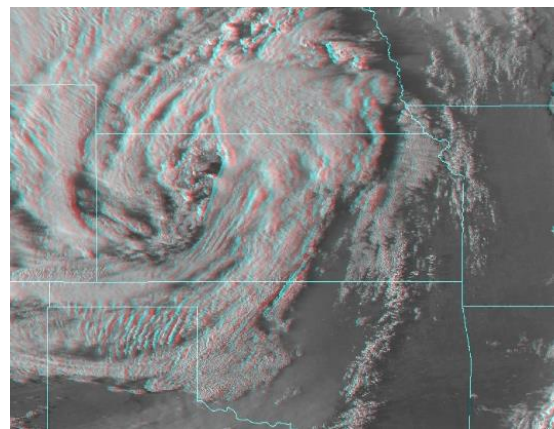
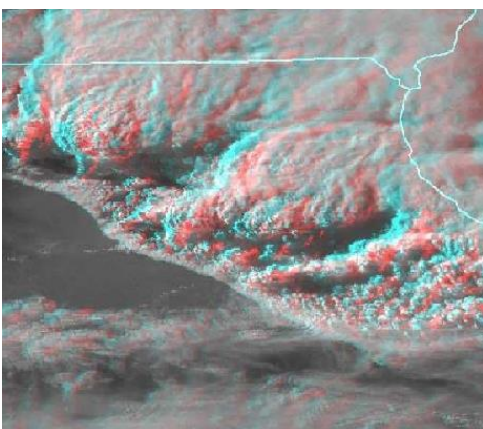


image from Viri Virtual Reality Melbourne facebook post

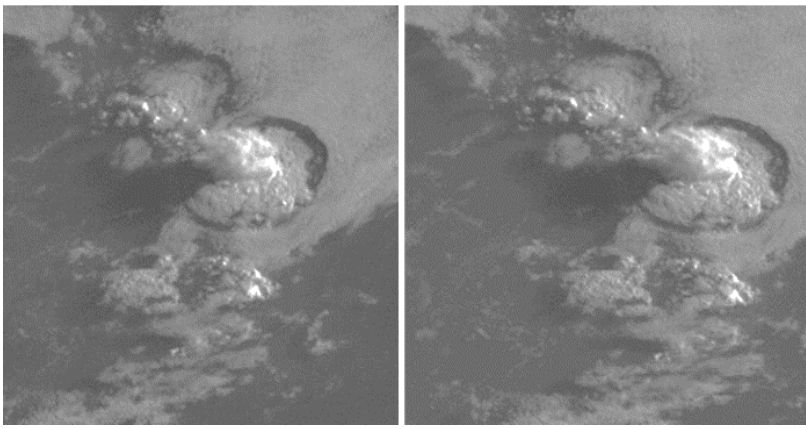
Advantages in using 3D stereo satellite imagery



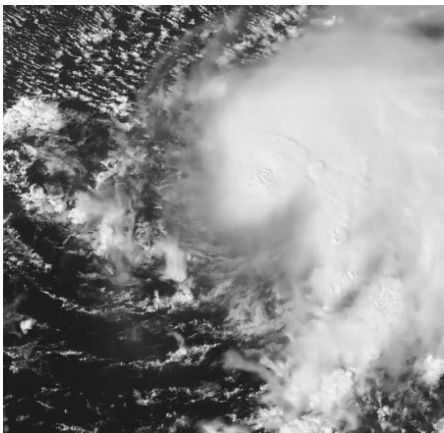
Analysing multilayer cloud, superior AMV's



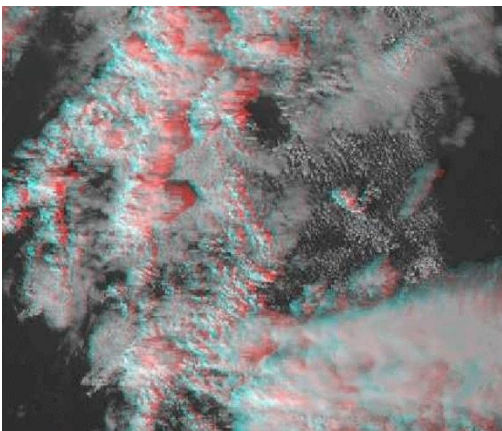
Analysing the interaction between low and upper levels of the atmosphere



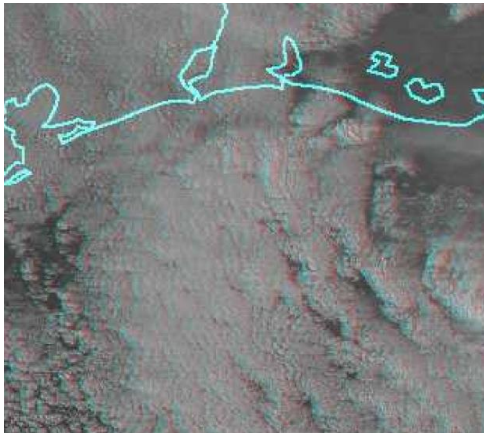
Analysing vertical motion of developing thunderstorms



Analysing atmospheric shear and trends in these



Better monitor low cloud below broken higher cloud

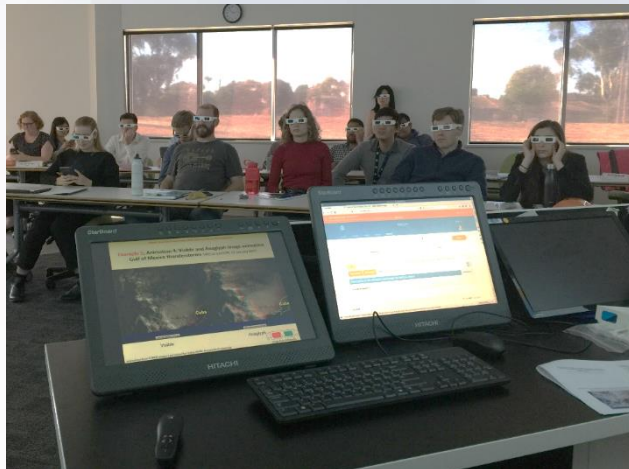


Detection of minor variations in height for oceanic cellular convection

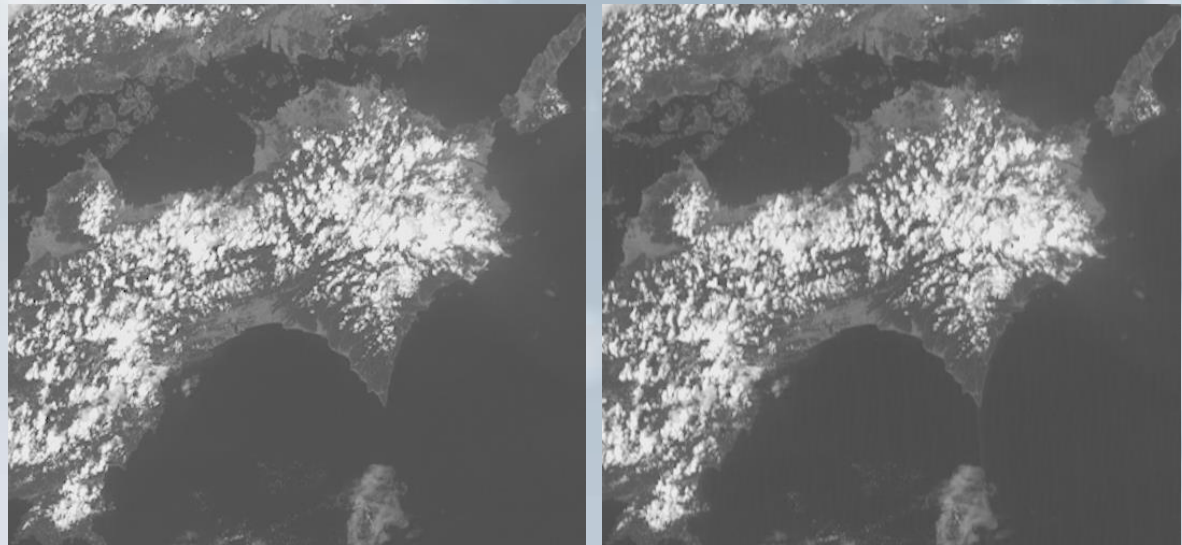
Suggested use of 3D stereo satellite imagery within a meteorological forecasting / training centre



Selective use by severe weather forecasters to gain greater insight into a difficult situation



Enhanced teaching of
meteorological principles to
Trainee Meteorologists



Normal animation and Wiggly 3D animation in two panel display



Australian Government

Bureau of Meteorology

Summary

- The constellation of geostationary satellites over our region
- Utilising limb effects for enhanced forecaster monitoring
- Introducing the 3D stereo satellite imagery utilising Himawari-8, Geo-KOMPSAT 2A, GOES-16 and 17 data