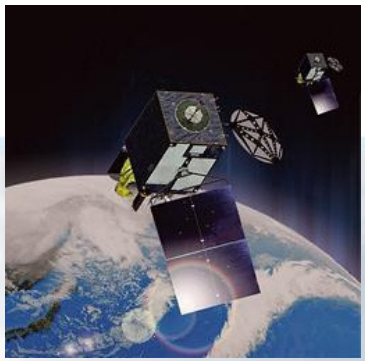
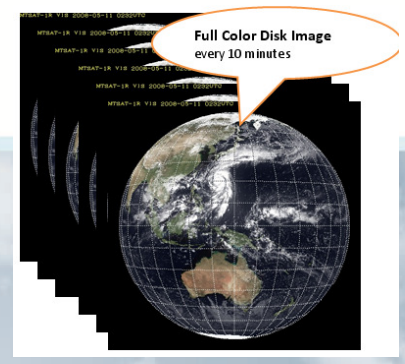
Australian Government
Bureau of Meteorology

# Advanced Satellite Meteorology






Session 5: Training in the use of Rapid Scan (10 minute) data

Bodo Zeschke
Bureau of Meteorology Training Centre
Australian VLab Centre of Excellence

# Advanced Satellite Meteorology Course

| | |
|---|---|
| Session 1<br>10th June | Advanced training in the use of visible and infrared satellite imagery. |
| Session 2<br>14th June | Advanced training in the use of water vapour satellite imagery. |
| Session 3<br>15th June | Training in the use of microwave scatterometer data |
| Session 4<br>17th June | Training in the use of cloud drift wind data (presented by John LeMarshall) |
| **Session 5<br>20th June** | **Training in the use of rapid scan data.** |
| Session 6<br>21st June | Training in the use of RGB products |
| Practical sessions / Revision session (22nd , 23rd, 27th June) | Practical sessions focus upon Rapid Scan and RGB Product data |
| **2 hour exam (1st July)** | **Open book exam with resources on latitude** |

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# Material Covered

**Delivery of Himawari 8/9 data including data latency.**

**Some uses of rapid scan (10 minute) data – Forecaster feedback:**

- On the broad-scale, including synoptic scale wind flow
- Tropical Cyclone monitoring and short-term forecasting
- Thunderstorm monitoring and short-term forecasting
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- Smoke and Fire Monitoring, comparison with NWP

**Summary case study – rapid scan and synoptic features on the broadscale**

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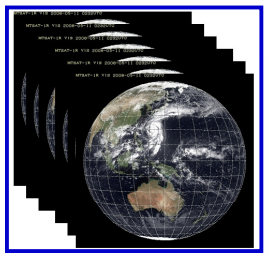
**Summary case study – rapid scan and synoptic features on the broadscale**

## Changes from MTSAT-2 to Himawari-8

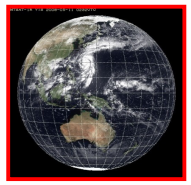
| Band | Central Wavelength [μm] | Spatial Resolution |
|---|---|---|
| 1 | 0.43 - 0.48 | 1Km |
| 2 | 0.50 - 0.52 | 1Km |
| 3 | 0.63 - 0.66 | 0.5Km |
| 4 | 0.85 - 0.87 | 1Km |
| 5 | 1.60 - 1.62 | 2Km |
| 6 | 2.25 - 2.27 | 2Km |
| 7 | 3.74 - 3.96 | 2Km |
| 8 | 6.06 - 6.43 | 2Km |
| 9 | 6.89 - 7.01 | 2Km |
| 10 | 7.26 - 7.43 | 2Km |
| 11 | 8.44 - 8.76 | 2Km |
| 12 | 9.54 - 9.72 | 2Km |
| 13 | 10.3 - 10.6 | 2Km |
| 14 | 11.1- 11.3 | 2Km |
| 15 | 12.2 - 12.5 | 2Km |
| 16 | 13.2 - 13.4 | 2Km |

Himawari-8



10 minute images

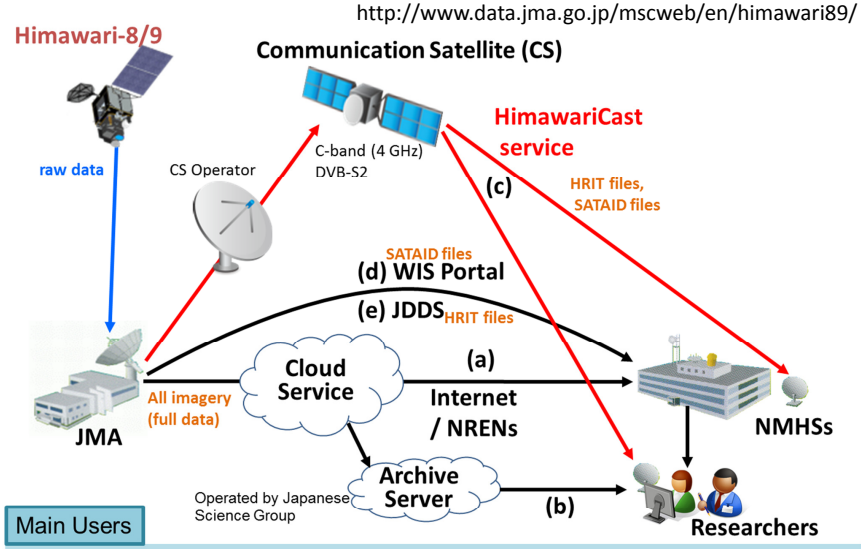
MTSAT-2



Hourly / half hourly images

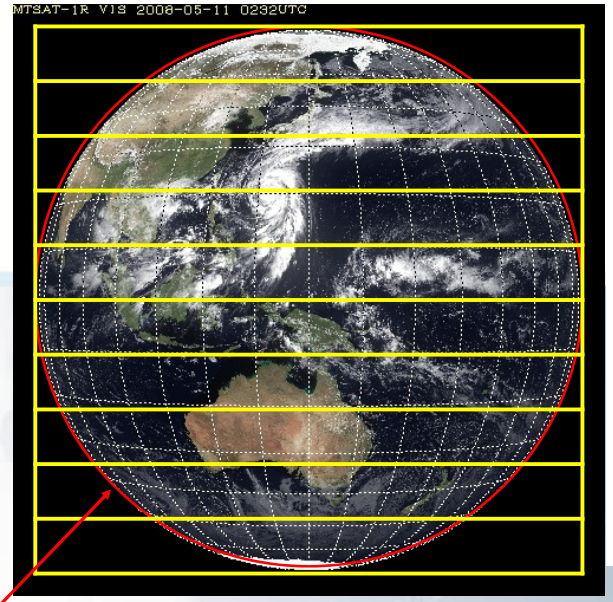
| Band | Central Wavelength [μm] | Spatial Resolution |
|---|---|---|
| 1 | 0.55 – 0.90 | 1Km |
| 2 | 3.50 – 4.00 | 4Km |
| 3 | 6.50- 7.00 | 4Km |
| 4 | 10.3 – 11.3 | 4Km |
| 5 | 11.5 – 12.5 | 4Km |

http://www.data.jma.go.jp/mscweb/en/himawari89/




Main Users

(a) Cloud Service: NMHSs (1 agency / nation)
(b) Archive Server: Universities and Researchers
(c) HimawariCast: Every users
(d) WIS Portal and (e) JDDS: NMHSs




Full disk
Interval: 10 minutes (6 times per hour)

## Data distribution

The data distribution (Cloud Service and HimawariCast) will be in segments,with 10 segments composing a full disk scan of 10 minute duration.

Each segment will be sent without landmark analysis, instead a prediction algorithm will be used to navigate the segments.

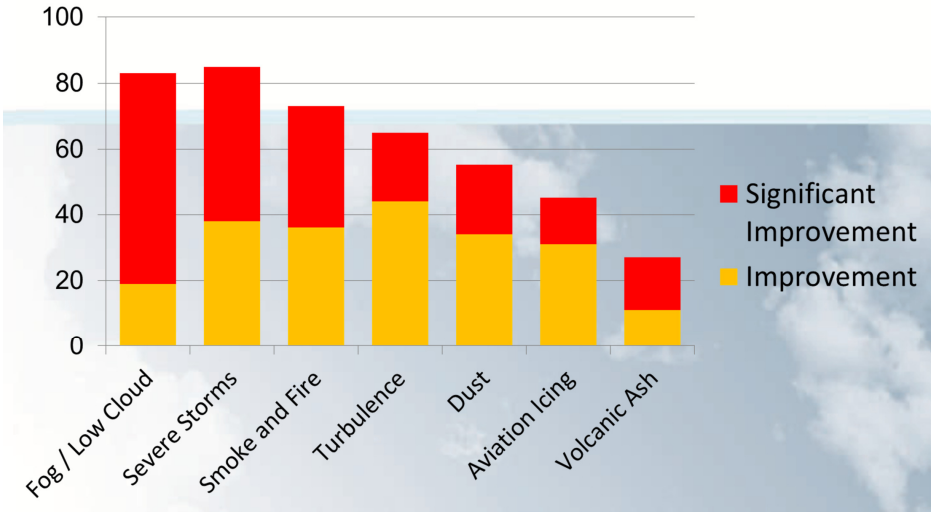
Image from "Status of Current and Future Satellite Programs of Japan Meteorological Agency" K. Bessho

## Himawari-8 data distribution

- The data distribution (Cloud Service and HimawariCast) will be in segments, with 10 segments composing a full disk scan of 10 minute duration. Landmark analysis will be conducted on the full disk scan. Each segment will be sent without landmark analysis, instead a prediction algorithm will be used to navigate the segments.
- From email from Denis Margetic, 20th June 2016 – Himawari-8 data latency
  - **00:00Z image satellite scan is completed: 00:10Z**
  - Data download is complete by 00:12Z
  - **IR 10 micron channel available to Forecasters 00:14Z**
  - **Data/imagery available to Forecasters: 00:17Z**
  - **Products available to Forecasters: 00:17Z**
- From correspondence with Leon Majewski, April 2017:
  - Altogether a 15-16 minute delay from datestamp to receipt. Next image follows 10 minutes afterwards.

**REFERENCE**

## Research "Impact of 10 minute Himawari-8 imagery on nowcasting at the Australian Bureau of Meteorology". Improvement in ability to detect/monitor the following severe weather elements compared to previous satellite data.



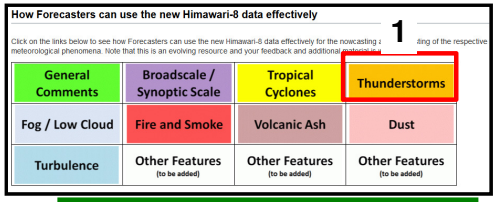

## General Comments about using 10 minute rapid scan data from Australian and Indonesian Forecasters

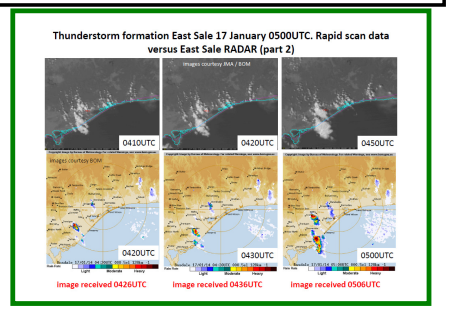
- Everyone I have talked to that has used the data has found it very useful for short lead time forecasting and weather watching (SL NSW RFC)
- The ability to reconcile the 10 minute satellite data with the 6 minute radar scans in real time (SL. NSW RFC)
- The visible images during the day allow for more accurate briefing to pilots of actual conditions (DS VIC RFC)
- Television reporters are also very interested in the rapid scan imagery (AS BMKG Indonesia)

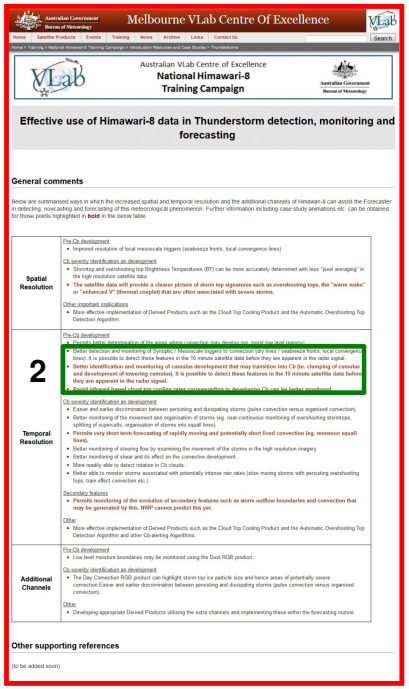
**REFERENCE**

## "How Forecasters can use the Himawari-8 data effectively"

([http://www.virtuallab.bom.gov.au/training/hw-8-training/introduction-resources-and-case-studies/](http://www.virtuallab.bom.gov.au/training/hw-8-training/introduction-resources-and-case-studies/) )

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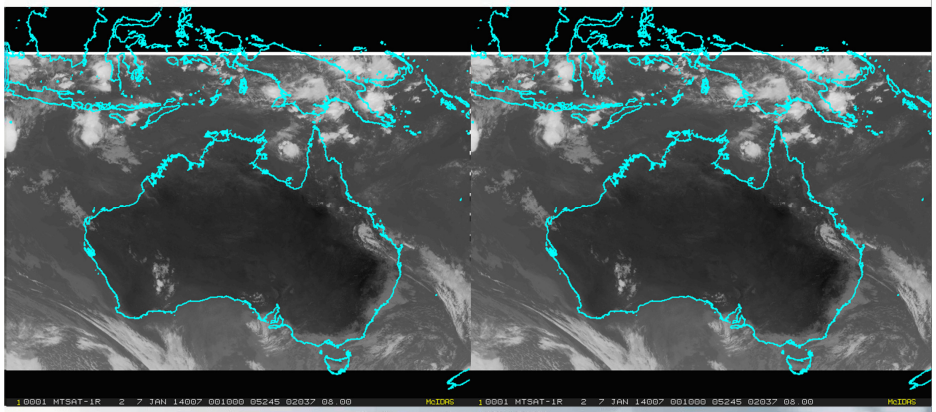
**Summary case study – rapid scan and synoptic features on the broadscale**

## 24 hour loop, IR data, 7th January 2014, full MTSAT-1R HIWC domain 10 minute data versus hourly data



animations courtesy JMA / BOM

10 minute imagery | Hourly imagery

**ANIMATION1**

| | Yes | No |
|---|---|---|
| **Question**: on this scale is 10 minute satellite data better than hourly data? Can you think of some reasons? | | |

**Please start the PowerPoint Slide Show to activate the animations**

## Forecaster feedback regarding the use of 10 minute satellite data in Broadscale analysis

- Forecasters prefer the "smoother" animation of rapid scan (10 minute) satellite data on the Broadscale.
- Useful in the initial Forecaster familiarisation. Using rapid scan animated satellite imagery is an efficient way to quickly locate the "weathermakers" and to obtain an initial feeling regarding the intensity trends and the temporal "vigorousness" in the activity of individual weather systems. This can save a lot of time on shift.
- Can better monitor interaction between Synoptic features such as Tropical Cyclone and broadscale shear, Tropical Cyclone and an amplifying upper trough, interaction between Polar and Subtropical Jets etc. in the rapid scan imagery.
- Modulation of convection by Tropical Waves can be better monitored.
- Broadscale Shear is better defined.

**REFERENCE**

## Monsoon Squalls

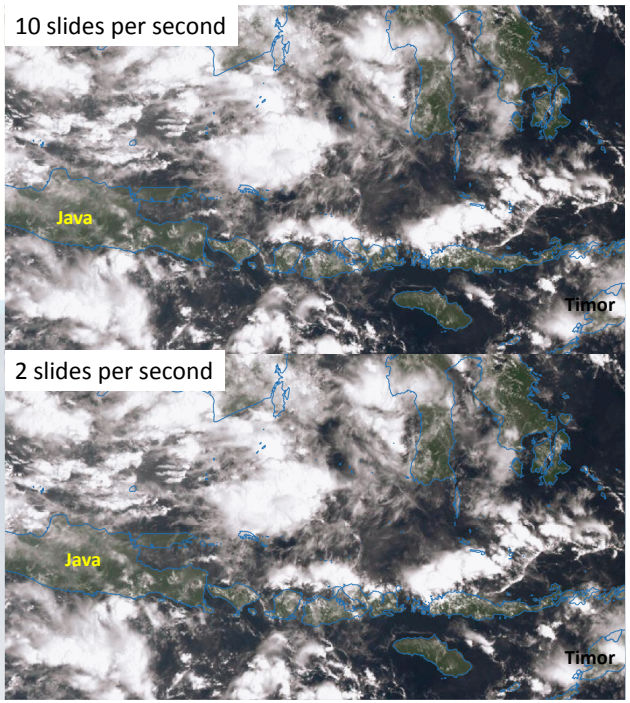
0140 to 0540UTC 29th February 2016

True Colour Visible animation from the Himawari-8 Data Viewer

**Question:** which animation speed do you prefer for monitoring the evolution of the squall line? Why?

**ANIMATION2**

animation courtesy BOM/JMA

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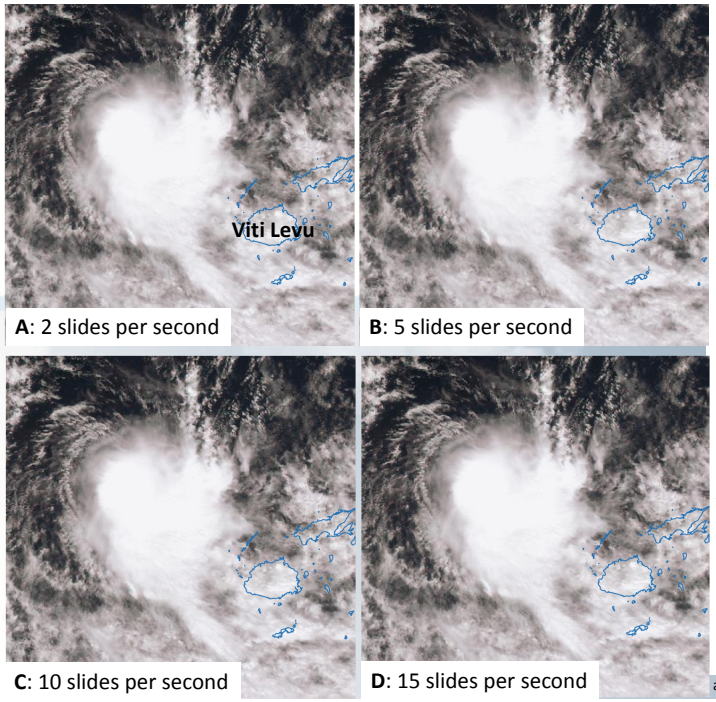



**Various speeds of animation – Low near Fiji, 17th October 2015**

**ANIMATION3**

**Question:** which animation speed best shows the dynamics

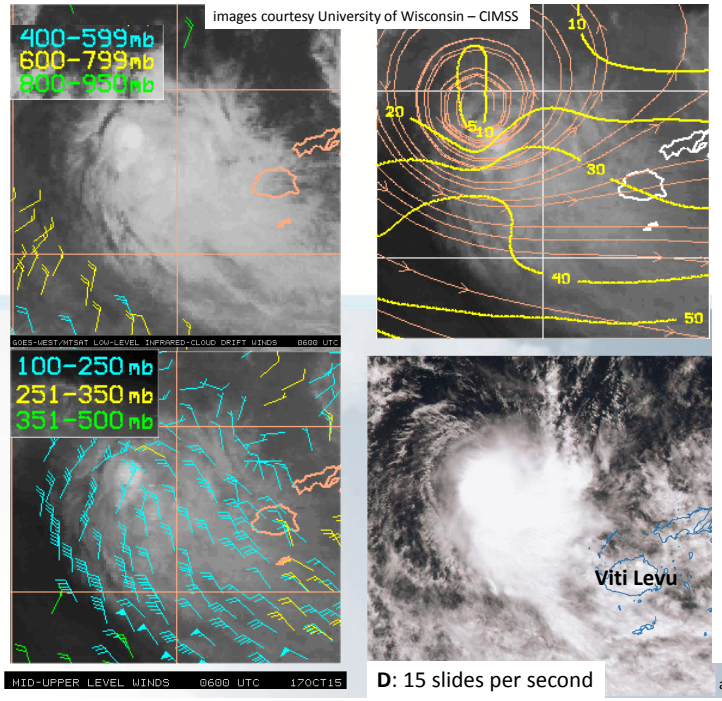
**Question:** what features can you recognise better under higher animation speeds?

animations courtesy BOM/JMA

## Accelerating the animation of Himawari-8 satellite data for improved analysis

- Stuart Coombs, a Forecaster at the VICRO RFC first alerted me of the usefulness of animating the 10 minute imagery to 10 frames a second in order to reveal subtle features in the synoptic and mesoscale flow.
- The human eye and its data reception and transmission system can form, transmit and analyse 10-12 images per second. The vision centre in the brain retains each individual image for one-fifteenth of a second. If the vision centre in the brain receives another image during this fifteenth of a second, the sight mechanism will create the sensation of visual continuity (Restoration of Motion Picture Film, Paul Read, Mark-Paul Meyer)
- The human eye and its brain interface, the human visual system, can process 10 to 12 separate images per second, perceiving them individually (Wikipedia)
- Persistence of vision may also create an illusion of continuity, allowing a sequence of still images to give the impression of motion (Wikipedia)

**REFERENCE**

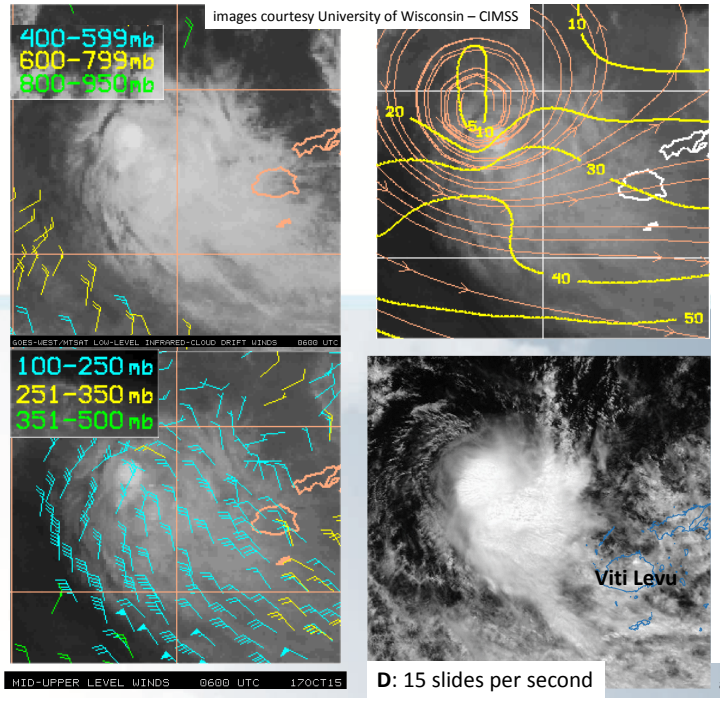



**ANIMATION4**

**Low near Fiji, 17th October 2015**

Combining **10 frame per second satellite data** with the low-mid level / mid-upper level cloud drift winds and the deep layer shear

animations courtesy BOM/JMA




**ANIMATION5**

**Low near Fiji, 17th October 2015**

Combining 10 frames per second **"rocking"** animated satellite data with the low-mid level / mid-upper level cloud drift winds and the deep layer shear

animations courtesy BOM/JMA

## Comments about monitoring Tropical Cyclone development using 10 minute data from Australian Forecasters

- In an evolving Tropical Cyclone cloud structure may change in a matter of hours. 10 minute data permits you to watch these changes and you can adjust your nowcasting / forecasting in accordance with this.
- Better fix on the system centre during the developing phase (low level cloud lines / low level circulation centre may be detected through thin cirrus) DG. QLDRO.
- Central circulation can be tied to the RADAR. CD NTRO
- "False Eyes" can be ruled out. HL. WA RFC
- Central convection can be monitored better.
- Effects of shear can be monitored CD NTRO

**REFERENCE**

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Bureau of Meteorology

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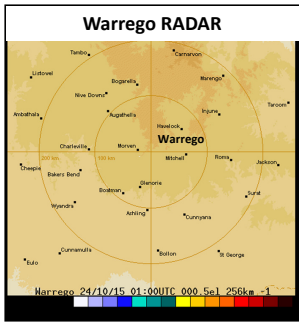
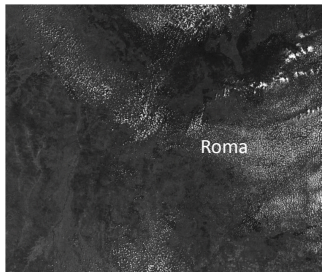
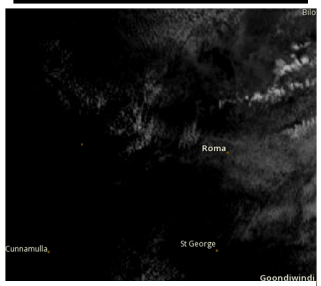
**Summary case study – rapid scan and synoptic features on the broadscale**

radar animation courtesy BOM

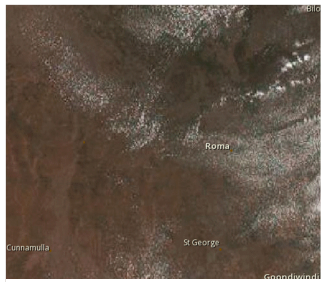



Visible channel (0.5km resolution)




Zehr enhanced IR (2km resolution)




True Colour RGB (2km resolution)




Temperature (C)

**ANIMATION6**

### Queensland storms

24th October 2015 01-05UTC
10 minute satellite data compared with RADAR

**Question:** how is the satellite data an advantage over RADAR data?

How is RADAR data an improvement over satellite data?

satellite animations courtesy BOM/JMA

## Himawari-8 satellite data latency compared to RADAR

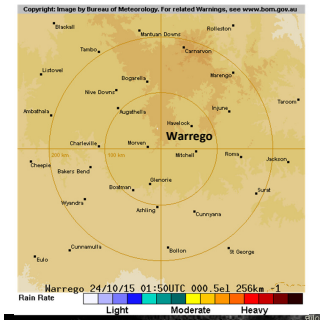
In particular the **RADAR data is typically received 6 minutes after the scan** (David Wright pers.comm).

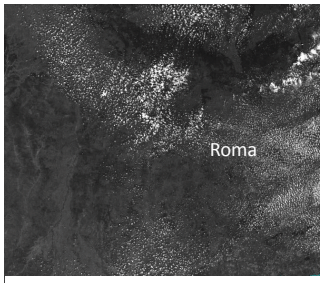
- From email from Denis Margetic, 20th June 2016 – Himawari-8 data latency
  - **00:00Z image satellite scan is completed: 00:10Z**
  - Data download is complete by 00:12Z
  - **IR 10 micron channel available to Forecasters 00:14Z**
  - **Data/imagery available to Forecasters: 00:17Z**
  - **Products available to Forecasters: 00:17Z**

**Summary** – RADAR available 6 minutes post scan
Himawari-8 data available after scanning Australia (segements 7-9) 6-11 minutes
So to make the RADAR/ satellite image comparison realistic we have compared satellite data with time stamp 10 minutes after the timestamp on the RADAR imagery

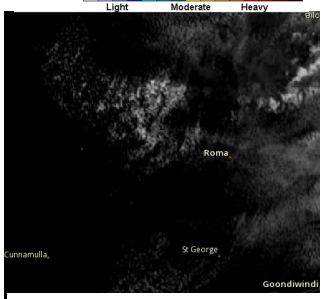
**REFERENCE**

radar image courtesy BOM

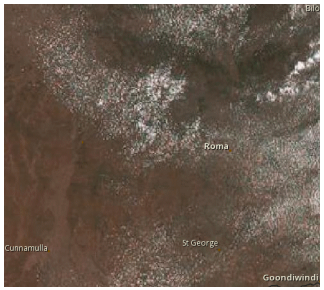



Visible channel (0.5km resolution)




Zehr enhanced IR (2km resolution)




True Colour RGB (2km resolution)


Temperature (C)

## Queensland storms

24th October 2015
0156UTC
10 minute satellite data compared with RADAR

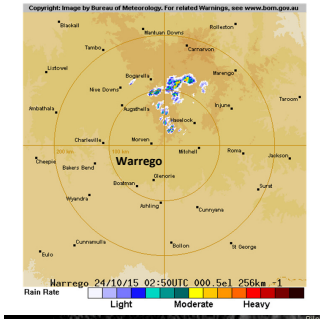
**Reception time on Forecaster screen ~0156UTC**

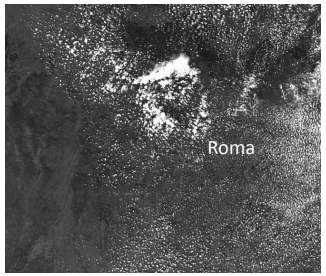
RADAR time stamp 0150UTC

Himawari-8 time stamp 0140UTC.

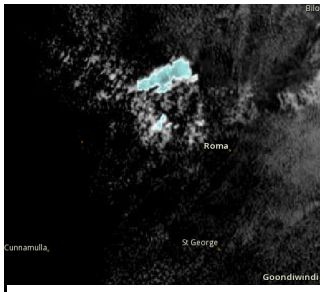
Satellite images courtesy BOM/JMA

radar image courtesy BOM

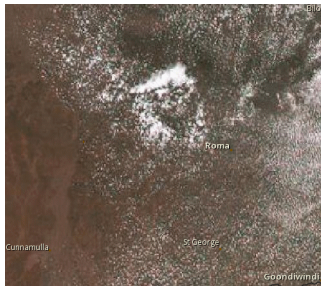



Visible channel (0.5km resolution)




Zehr enhanced IR (2km resolution)




True Colour RGB (2km resolution)


Temperature (C)

## Queensland storms

24th October 2015
0256UTC
10 minute satellite data compared with RADAR

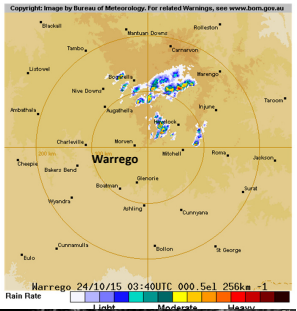
**Reception time on Forecaster screen ~0256UTC**

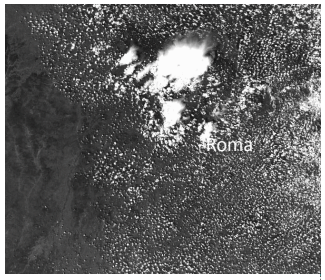
RADAR time stamp 0250UTC

Himawari-8 time stamp 0240UTC.

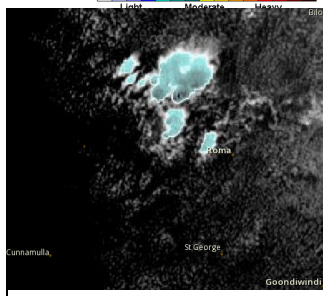
Satellite images courtesy BOM/JMA

radar image courtesy BOM

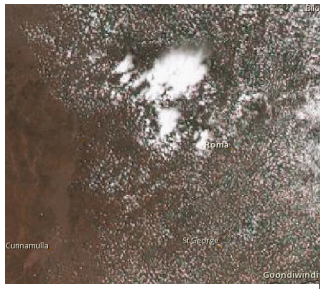


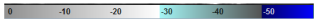

Visible channel (0.5km resolution)




Zehr enhanced IR (2km resolution)




True Colour RGB (2km resolution)




Temperature (C)

## Queensland storms

24th October 2015
0356UTC
10 minute satellite data compared with RADAR

**Reception time on Forecaster screen ~0356UTC**

RADAR time stamp 0340UTC

Himawari-8 time stamp 0330UTC.

Satellite images courtesy BOM/JMA

**ANIMATION7**

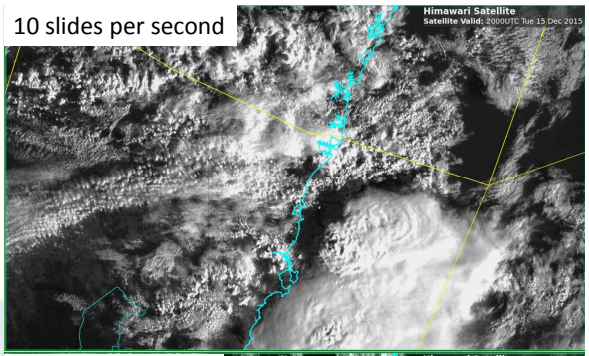
## Kurnell Tornado Storm

20UTC 15th December – 00UC 16th December 2015
Himawari-8 Band 3 visible imagery

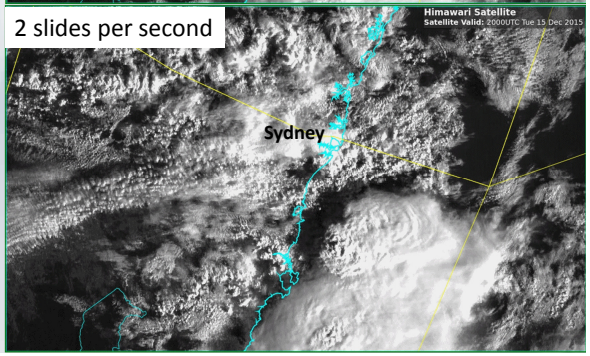
**Question:** which animation speed do you prefer for monitoring the evolution of the squall line? Why?

animation courtesy BOM/JMA

10 slides per second




2 slides per second



## Comments about monitoring storm development using 10 minute rapid scan data from Australian Forecasters

- The ability to pick up areas where convection is developing (eg. mesoscale / synoptic boundaries) earlier than via the RADAR (SL. NSW RFC)
- Better monitoring of Cu field development and transition into areas of Cb (monitoring "clumping of Cu")
- Able to determine the intensity of convective development, how quick storms develop and whether cell are long lived, or up-and-down (HL. WA RFC)
- Monitoring stormtops (overshooting tops including those of short lifespan, changes of brightness temperature over time)
- Monitoring features that develop after storm formation and that NWP cannot forecast (storm outflow boundaries)

**REFERENCE**

Australian Government
Bureau of Meteorology

## Material Covered

**Delivery of Himawari 8/9 data including data latency.**

**Some uses of rapid scan (10 minute) data – Forecaster feedback:**

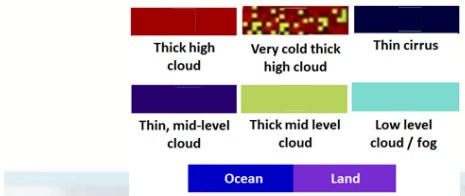
- On the broad-scale, including synoptic scale wind flow
- Tropical Cyclone monitoring and short-term forecasting
- Thunderstorm monitoring and short-term forecasting
- Fog and low cloud monitoring – multiple display windows
- Smoke and Fire Monitoring, comparison with NWP

**Summary case study – rapid scan and synoptic features on the broadscale**

**ANIMATION8**

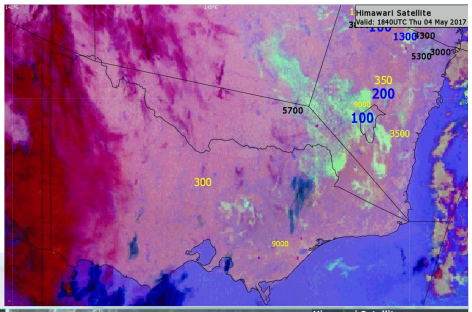
## Southeast Australia

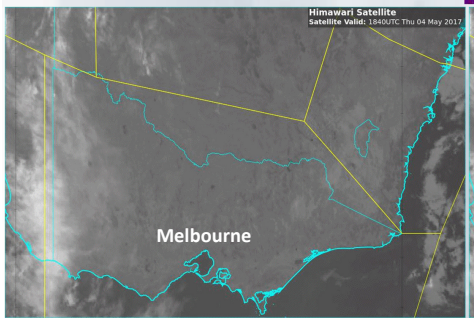
1840UTC to 2320UTC 4th May 2017



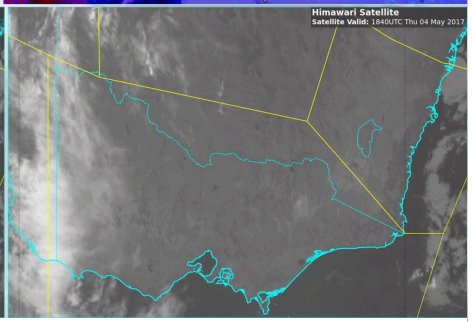

animations courtesy JMA/BOM

Night Microphysics RGB / True Colour RGB products




short wave infrared (3.9micron)




Infrared (10.4 micron) / visible

## Fog/low cloud detection example; southeast Australia, 4th May 2017 notes

The Night Microphysics RGB has been voted the most popular product during the survey of 115 Bureau Operational Forecasters during early 2017

In the Night Microphysics RGB / True Colour animation you can see the benefit of the additional dimension of colour in assisting in the identification of the fog and low cloud and distinguishing this from higher cloud and from the earths surface. Station visibility and cloud base information has been added to this data.

The infrared / visible loop is in greyscale and does not have the added dimension of colour. However, the Band 3 visible channel shown here has 0.5 km resolution which is better than the 1 km resolution of the True Colour RGB.

Forecasters which Colour Vision Impairment prefer to use the Short Wave Infrared channel data. However we are investigating the possibility of adapting Himawari-8 products for these Forecasters

**REFERENCE**

## Comments about monitoring fog development using 10 minute rapid scan data from Australian Forecasters

- The 10 minute visible imagery was very useful in monitoring the movement of the fog and determining its trajectory (rate of extension) and clearance" (VR SARO RFC).
- The visible images during the day allow for more accurate briefing to pilots of actual conditions (DS VIC RFC)
- The frequent animation of the imagery makes it possible to follow the development of the fog/low cloud in the shortwave infrared channel (3.9 microns) and this can assist Forecasters with colour vision impairment (NTRO RFC)

**REFERENCE**

Australian Government
Bureau of Meteorology

## Material Covered

**Delivery of Himawari 8/9 data including data latency.**

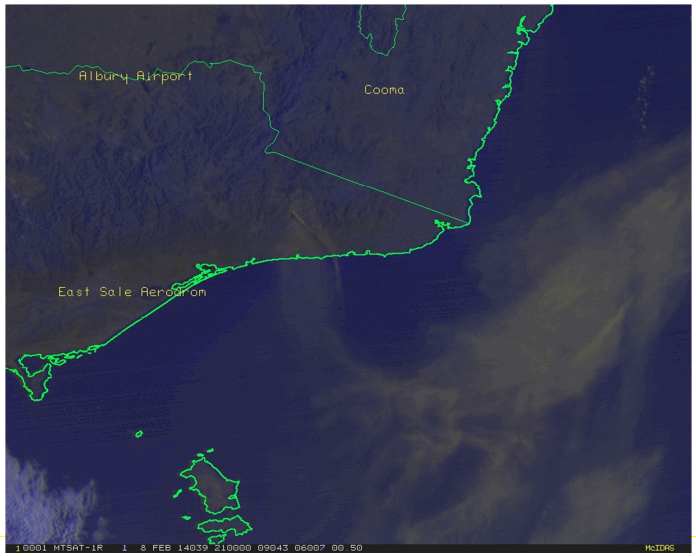
**Some uses of rapid scan (10 minute) data – Forecaster feedback:**

- On the broad-scale, including synoptic scale wind flow
- Tropical Cyclone monitoring and short-term forecasting
- Thunderstorm monitoring and short-term forecasting
- Fog and low cloud monitoring – multiple display windows
- Smoke and Fire Monitoring, comparison with NWP

**Summary case study – rapid scan and synoptic features on the broadscale**

## Fire development and the passage of a shallow cold front SE Victoria, 9th February 2014

(MTSAT-1R rapid scan vis/vis/ir RGB product, 10 minute data)

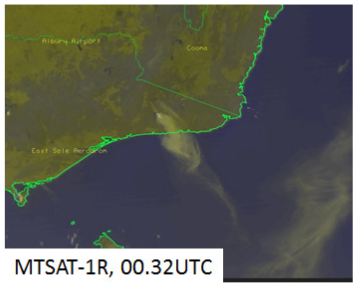


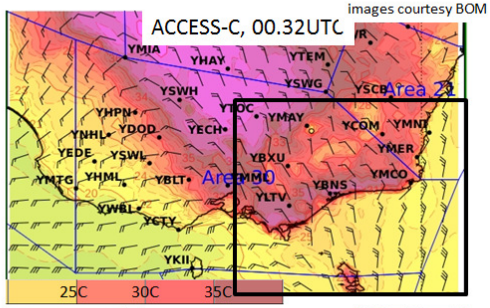

animation courtesy BOM / JMA

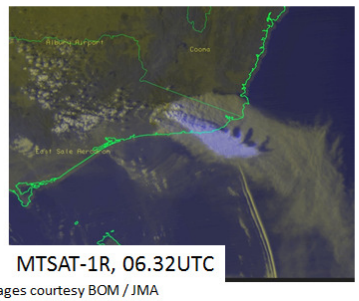
**ANIMATION9**

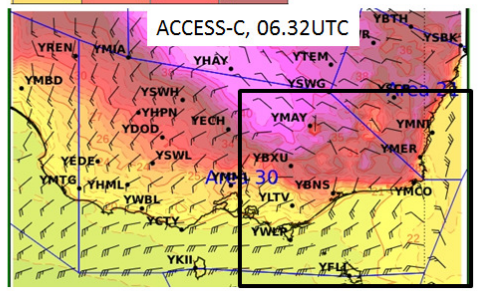
## Fire development and cold front SE Victoria, 9th February 2014

(MTSAT-1R rapid scan vis/vis/ir RGB product, ACCESS-C 10m wind and temperature)




images courtesy BOM

images courtesy BOM / JMA

## Fire development and cold front SE Victoria, 9th February 2014

(MTSAT-1R rapid scan vis/vis/ir RGB product, RADAR data received at the same time)

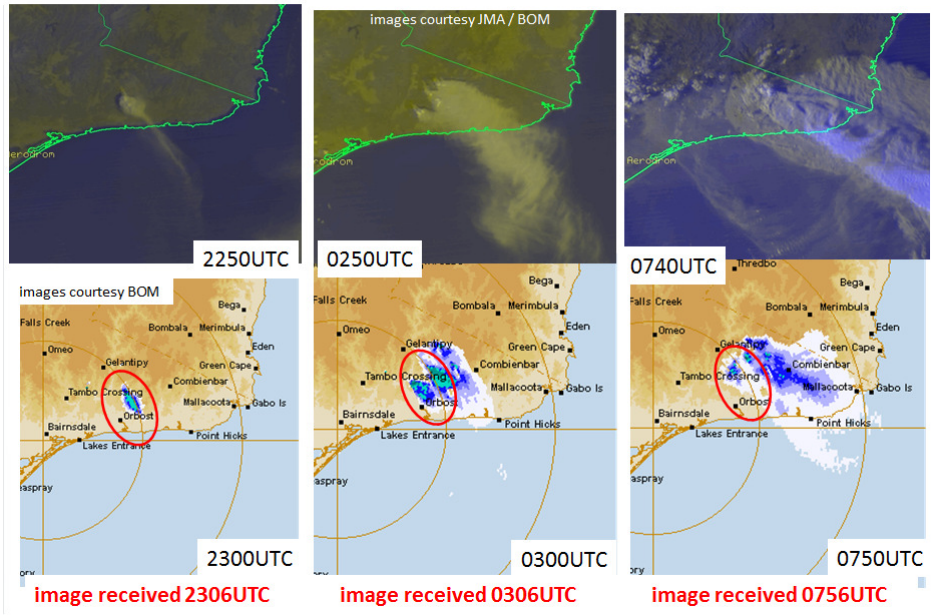
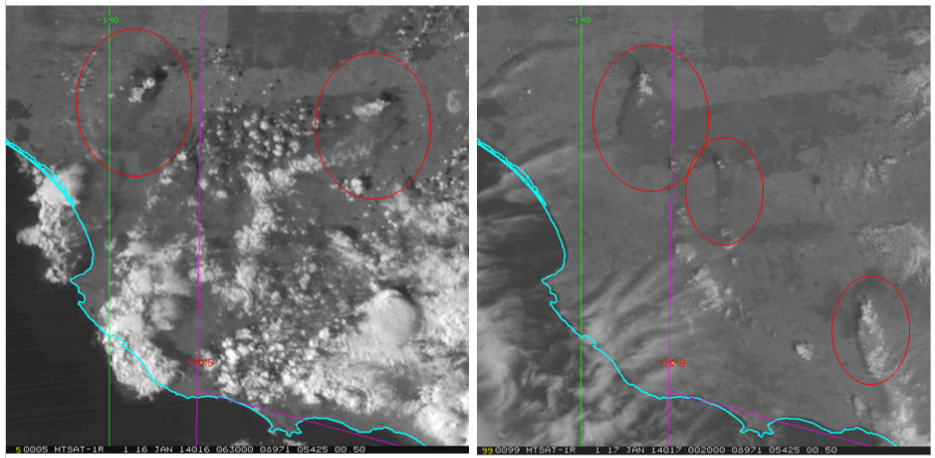



image received 2306UTC | image received 0306UTC | image received 0756UTC

## Smoke in the visible imagery

**Southwest Victoria Fires 16/17 January 2014 – during the day**

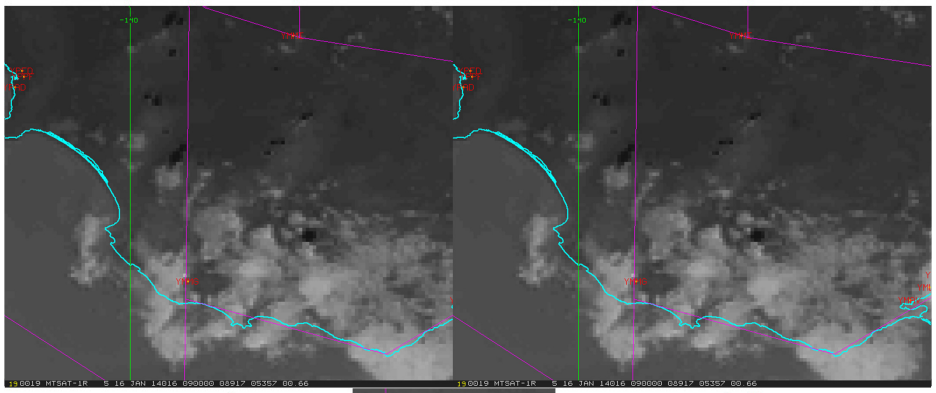


images courtesy BOM / JMA

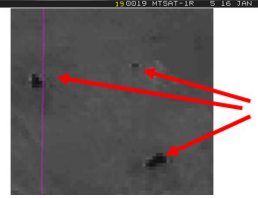
Evening of the 16th (0630UTC) | Morning of the 17th (0020UTC)

## Hotspots as detected in the 3.9 micron channel

**Southwest Victoria, overnight 16th / 17th January 2014**



10 minute data | Hourly data



Near Infrared images

"hotspots" from fires

animations courtesy BOM / JMA

ANIMATION10

## Comments about monitoring fire / smoke using 10 minute rapid scan data from Australian Forecasters

- "The ability to very easily pick when a plume from a bushfire has transitioned into pyro-convective behaviour (this has helped me a lot on quite a number of days" (SL. NSW RFC)
- The10 minute data permits a more continuous monitoring of the fires. "Have also been told that (10 minute data) is used for the smoke trajectory of fires" (HL. WA RFC)
- Monitoring of fire hotspots in the near-infrared (3.7 micron channel) assists in monitoring the fires during the night.

REFERENCE

Australian Government
Bureau of Meteorology

# Material Covered

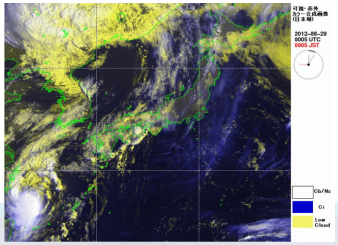
**Delivery of Himawari 8/9 data including data latency.**

**Some uses of rapid scan (10 minute) data – Forecaster feedback:**

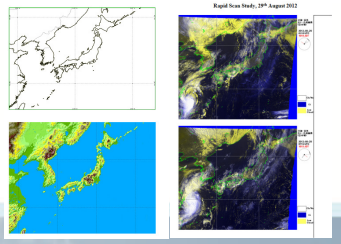
- On the broad-scale, including synoptic scale wind flow
- Tropical Cyclone monitoring and short-term forecasting
- Thunderstorm monitoring and short-term forecasting
- Fog and low cloud monitoring – multiple display windows
- Smoke and Fire Monitoring, comparison with NWP

**Summary case study – rapid scan and synoptic features on the broadscale** - a past exam question

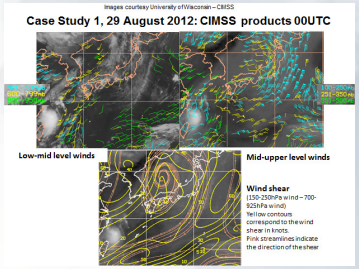
# Exercise 1: Rapid Scan Study: How to conduct this brainstorming / data mining session (see handouts)



1 - watch animation on computer



2 – panel display for annotations




3 – additional data

**Question** – Examine the rapid scan animation as shown on the board

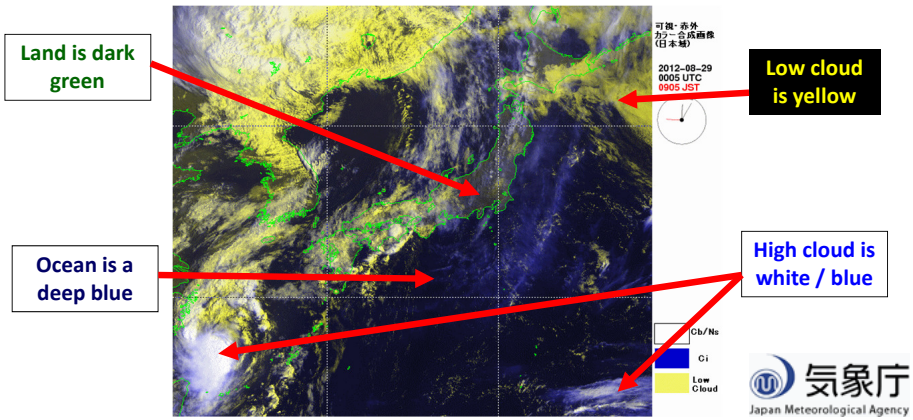
a) Describe as many features of interest to the Forecaster whilst examining the animation on the screen in front of the classroom. Also refer to the CIMSS resources in this handout. You may annotate your answers on the spaces below and overleaf. You may wish to use the map below to help you answer this question. A topographical map is also provided.

b) Give reasons why the features would be of interest to the forecaster

4 – questions to answer

# Rapid Scan Study, 29 August 2012: explaining the slide

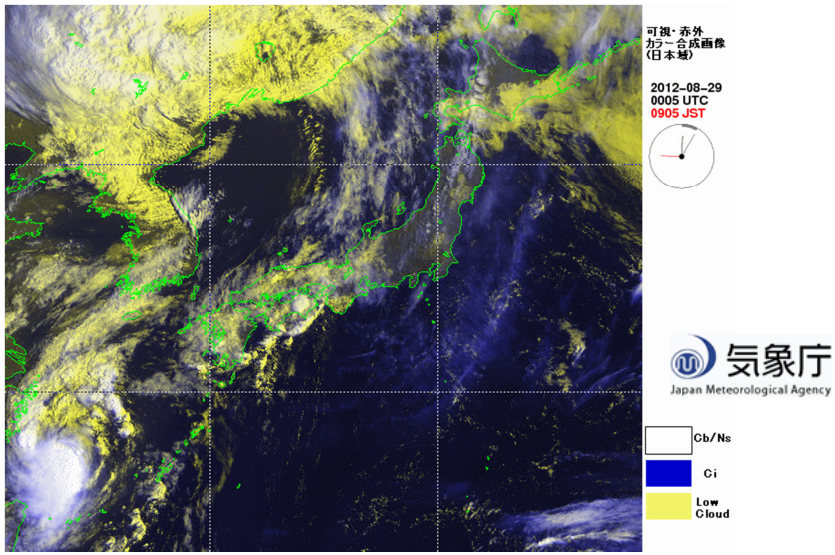
This is a Red-Green-Blue (RGB) product where the Red and Green beams are represented by the visible channel (0.7 micron) and the Blue beam by the infrared channel (10.8 micron)




These files were provided by Himawari-6 (MTSAT-1R) Rapid Scan Observations. These were performed for the sake of aviation users. Japanese Meteorological Agency

ANIMATION11

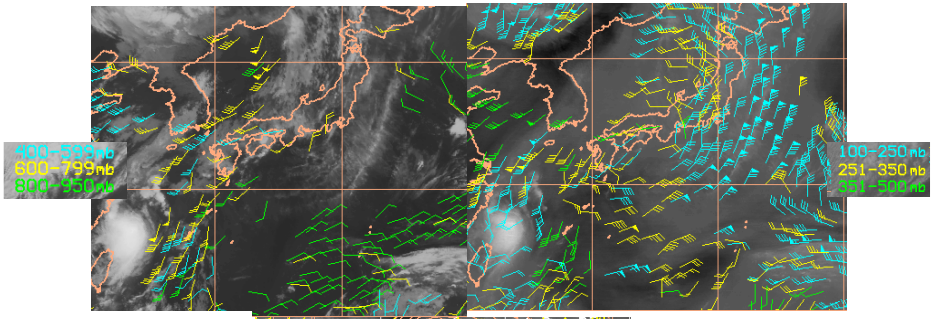
# Rapid Scan Study, 29 August 2012




These animation files were provided by Himawari-6 (MTSAT-1R) Rapid Scan Observations. These were performed for the sake of aviation users. Japanese Meteorological Agency.

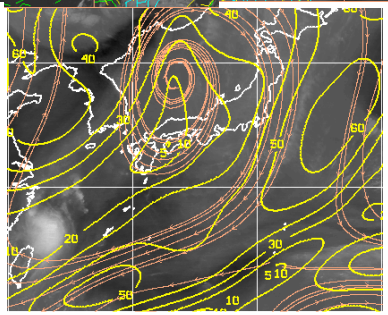
Images courtesy University of Wisconsin – CIMSS

## Exercise 1: 29 August 2012: CIMSS products 00UTC




**Low-mid level winds**

**Mid-upper level winds**

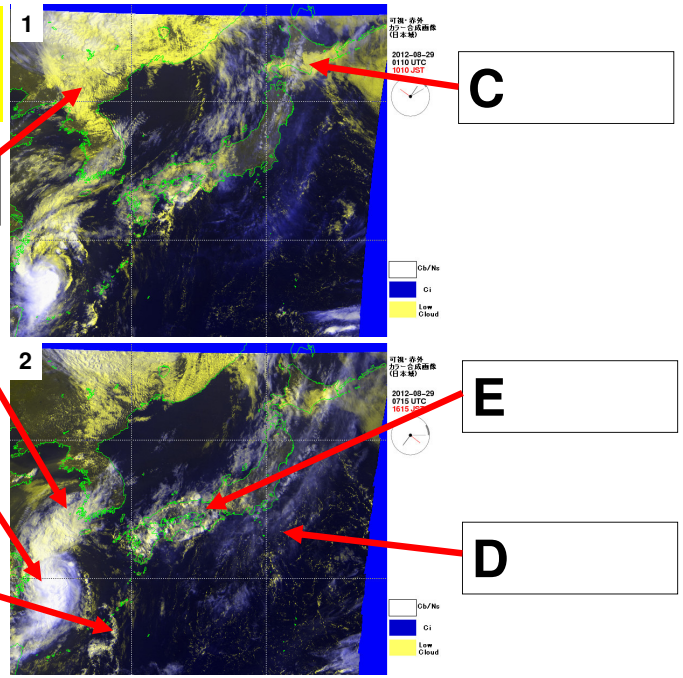


**Wind shear**
(150-250hPa wind – 700-925hPa wind)
Yellow contours correspond to the wind shear in knots.
Pink streamlines indicate the direction of the shear

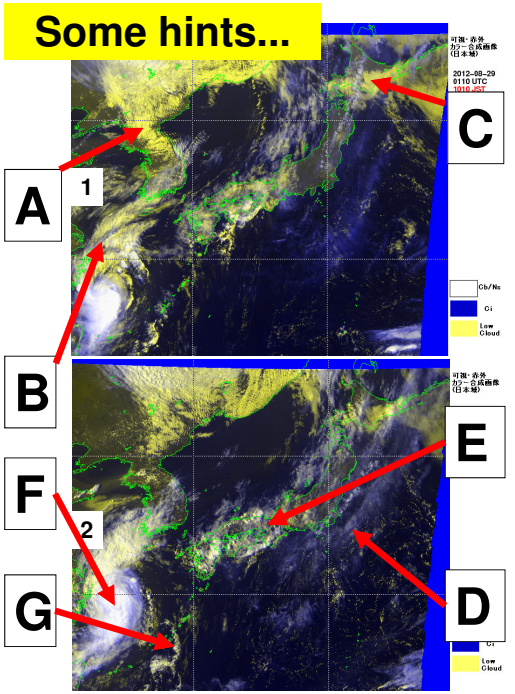
## Exercise 1: Rapid Scan Study, 29 August 2012 : Questions

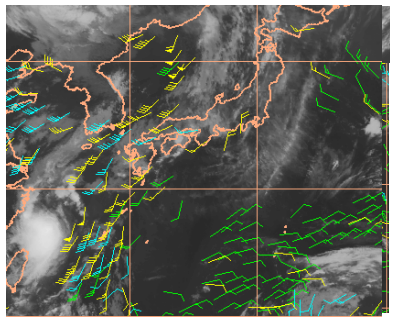
- Examine the rapid scan animation as shown on the board
- Utilising the 2 panels overleaf and the space below for this question, describe as many features of interest to the forecaster in this animation. You may wish to use the map below to help you answer this question. A topographical map is also provided. You may also refer to the CIMSS resources on the third page.
- Give reasons why the features would be of interest to the forecaster

## Some hints...

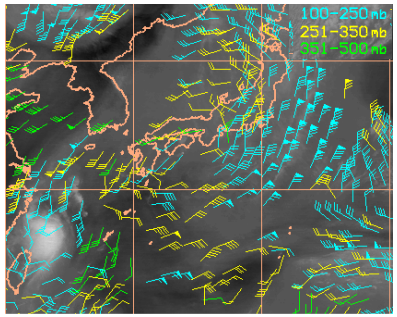



## Some hints...

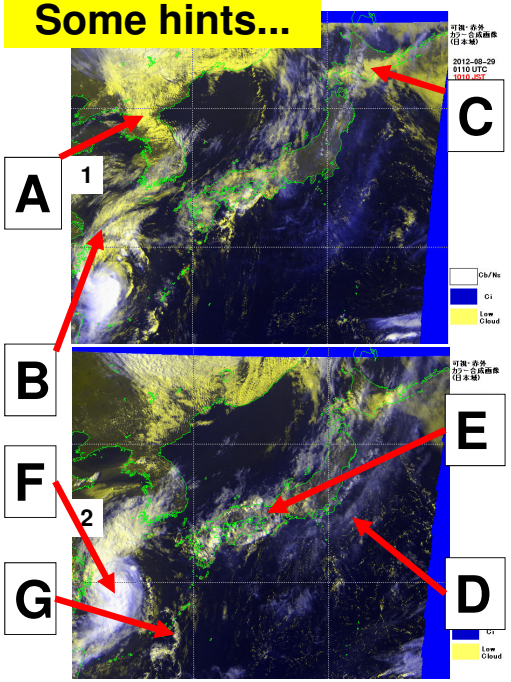


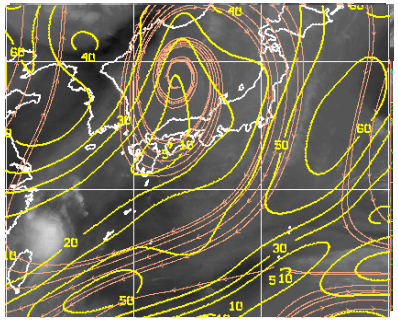



Above – low/mid level CIMSS AMV
Below – mid/upper level CIMSS AMV

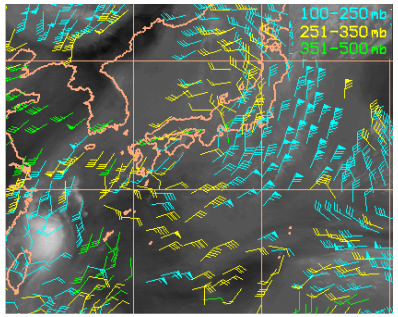


## Some hints...



Above – wind shear CIMSS AMV
Below – mid/upper level CIMSS AMV




## Summary

We have examined the 10 minute imagery and its impact on the Forecaster:

- Data distribution and latency
- Forecaster feedback pertaining to the use of this data for:
  - Broadscale and synoptic scale wind flow
  - Tropical Cyclone monitoring and short-term forecasting
  - Thunderstorm monitoring and short-term forecasting
  - Fog and low cloud monitoring and short-term forecasting – multiple display windows
  - Smoke and Fire Monitoring, comparison with NWP
- We have reinforced this learning and prepared for the subject exam by participating in a summary case study