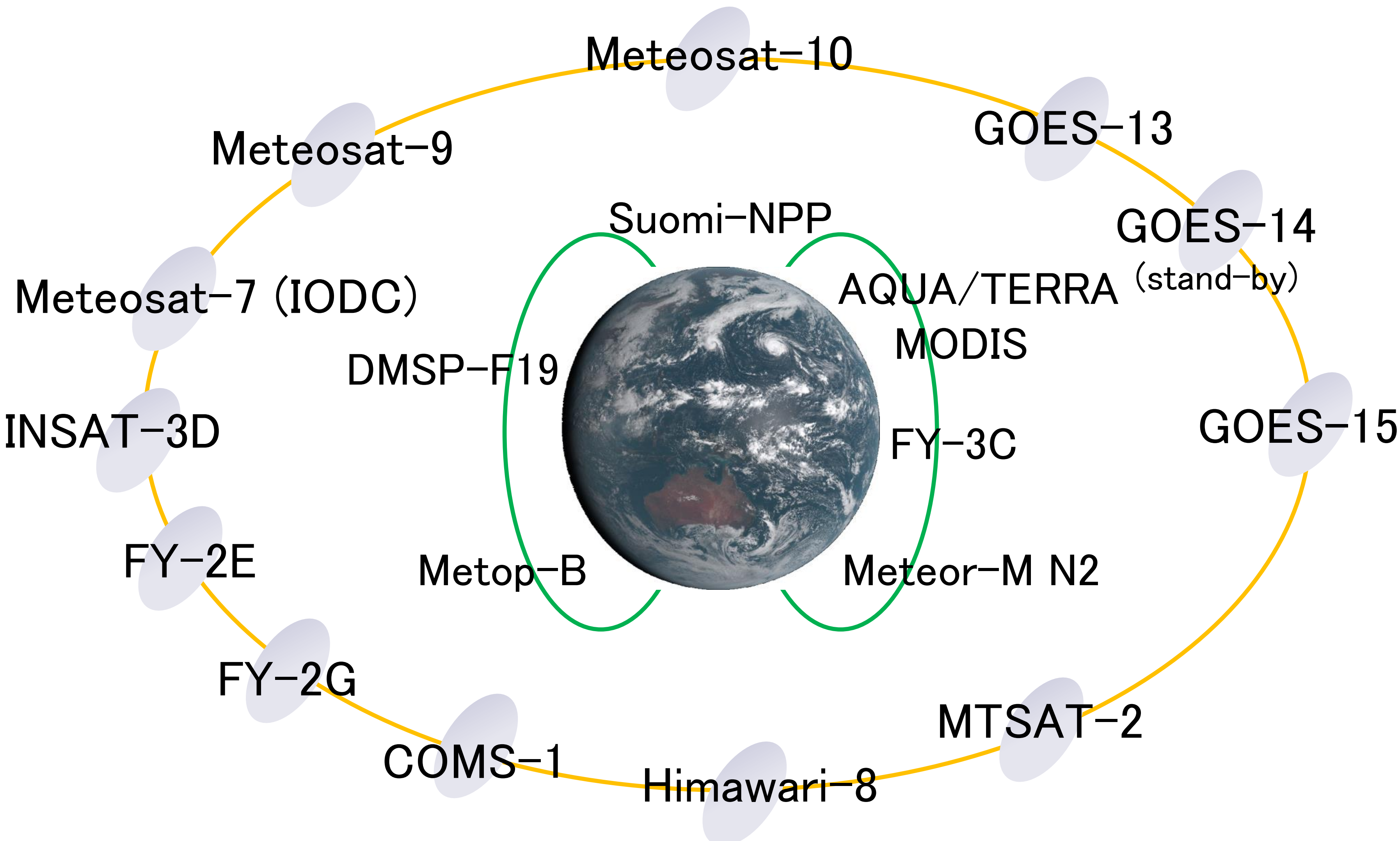
VAAC challenges and opportunities

- Monitoring volcanic ash with the next generation of satellite platforms -

19 October 2015

Meteorological satellites in the world



Reference: WMO Web Page (13 June 2015)

Roles of satellite for VAAC operations

VAACs are designated as centers to

- Monitor volcanic eruptions
- Provide information on the locations and movement of volcanic ash cloud
- Provide information on an forecast/outlook for their regions of responsibility
- Provide information to the MWO, Airlines and other users through briefings

When volcanic ash clouds are identified from satellite imagery, VAACs issue advisories at least in 6 hours intervals
(they also issue advisories when eruption info is sent from the MWO, volcano observatories)

Satellites are

- one of the methods to identify volcano eruptions;
  useful especially for those without enough ground observation facilities

- satellites are used to estimate the extent and altitude of volcanic ash cloud
- satellites are used to estimate the speed of volcanic ash movement in some cases

New satellite Himawari-8

Himawari-8 data will lead to a better advisory provision

Band of MTSAT-2	Band	Central Wavelength [μm]	Spatial Resolution
	1	0.47	1 km
VIS	2	0.51	1 km
	3	0.64	0.5 km
	4	0.86	1 km
	5	1.6	2 km
	6	2.3	2 km
IR4	7	3.9	2 km
IR3	8	6.2	2 km
	9	6.9	2 km
	10	7.3	2 km
	11	8.6	2 km
	12	9.6	2 km
IR1	13	10.4	2 km
	14	11.2	2 km
IR2	15	12.4	2 km
	16	13.3	2 km

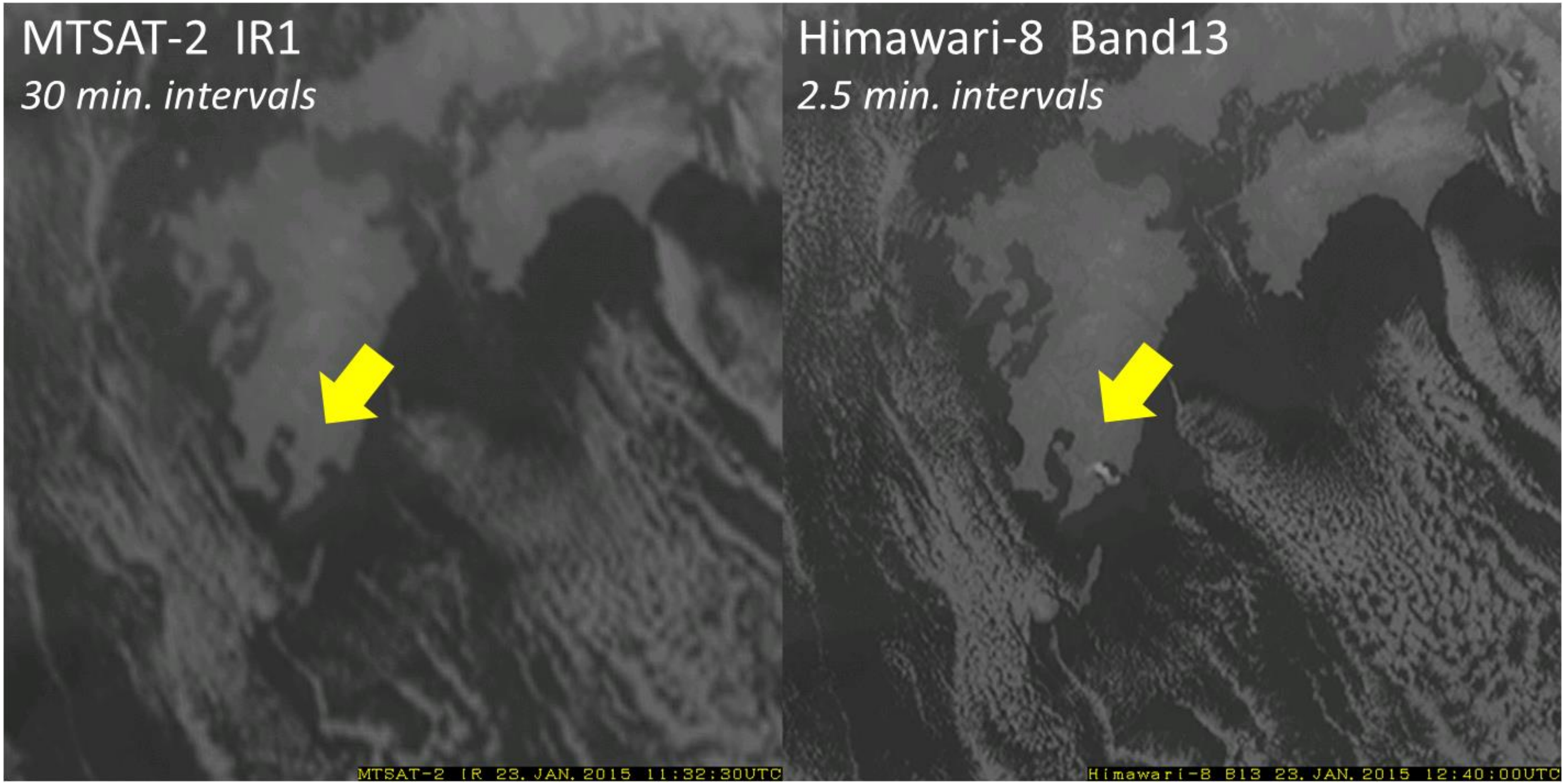
- Color imagery (bands 1–3)
- Higher resolution
- High-frequency observation
  → more timely advisory provision
- SO_2 detection (bands 10–11)
  → easier to identify volcanic ash

The data will also be beneficial to verify simulation results for ash extent.

New satellite Himawari-8

~ Sample movies for volcanic ash from Sakurajima ~

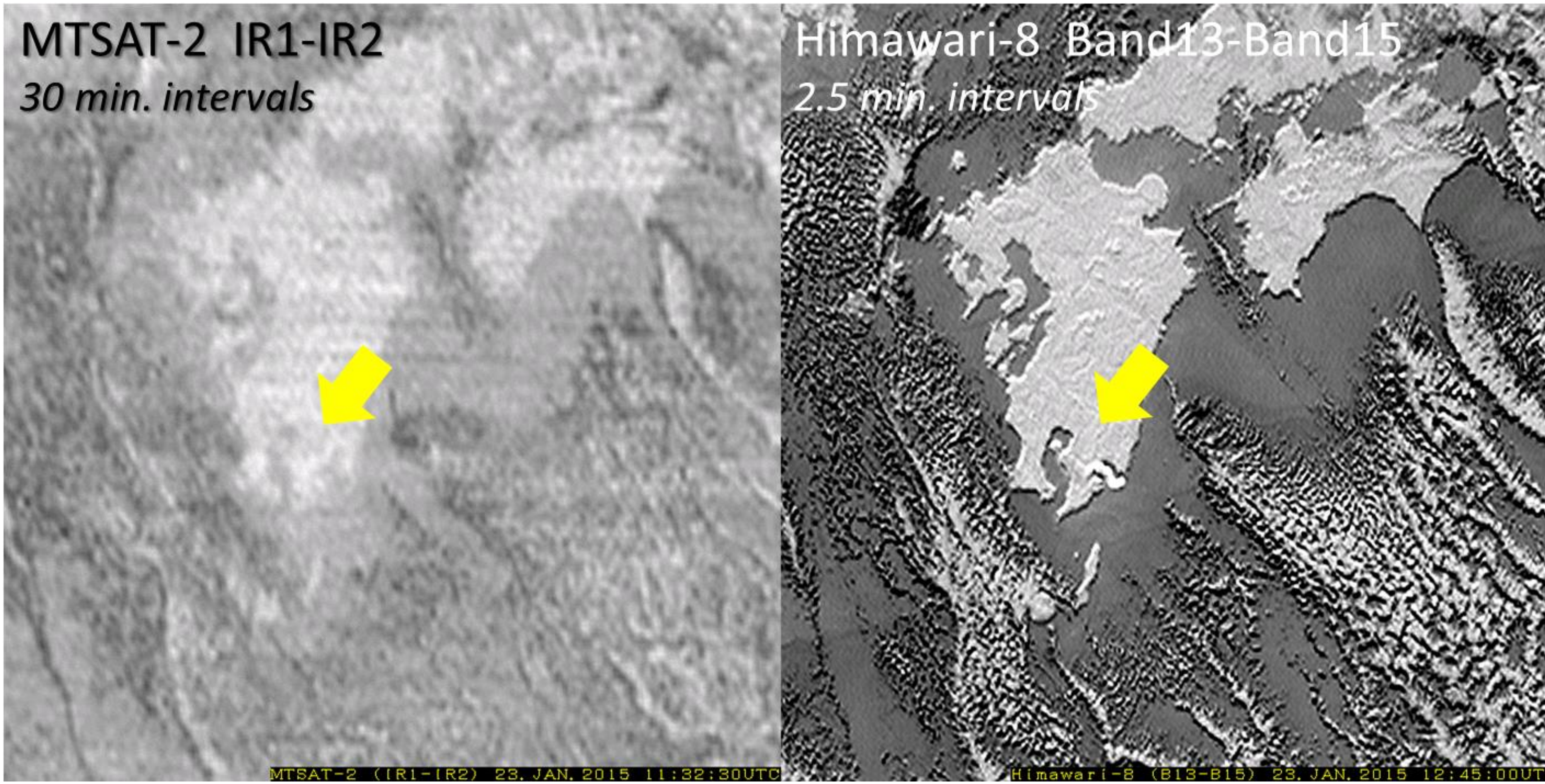
- Easy to track ash with imagery from Himawari-8



New satellite Himawari-8

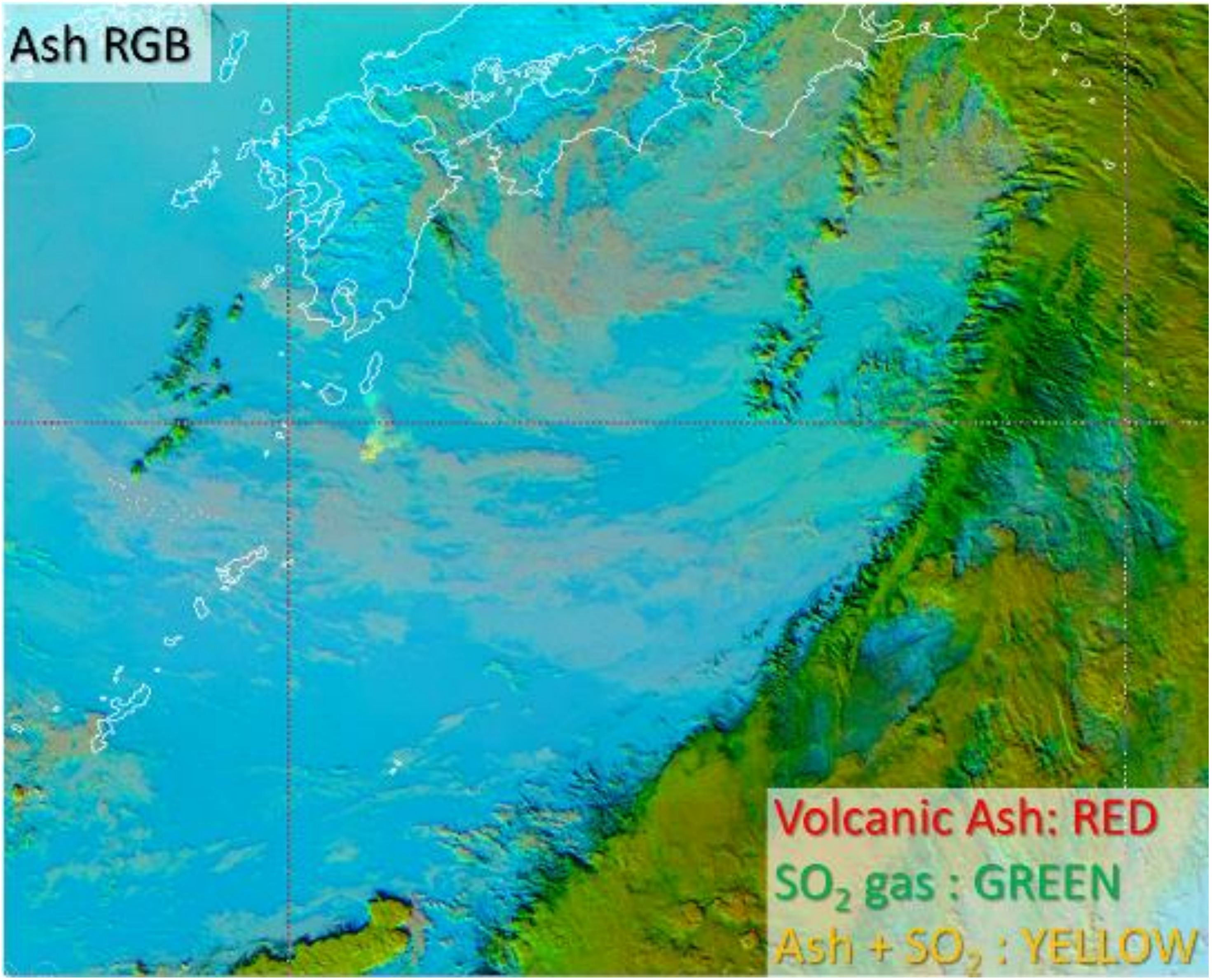
~ Sample movies for volcanic ash from Sakurajima ~

- Easy to track ash with imagery from Himawari-8



New satellite Himawari-8

~ Sample movies for volcanic ash from Kuchinoerabujima ~



GOES-R vs Current GOES Imagery

	GOES-R – ABI		Current GOES Imager
Spectral Coverage	16 bands		5 bands
Spatial Resolution			
0.64 um Visible	0.5 km	(1 channel)	1 km
visible/near-IR	1.0 km	(5 channels)	n/a
Bands (> 2 um)	2.0 km	(16 channels)	4 km
Spatial Coverage			
Full Disk	4 per hour (up to 12 per hour in continuous Full Disk)		3 hrly
CONUS	12 per hour		4 per hour
Mesoscale	Every 30 sec – 1 minute		RSO's/SRSO only

GOES-R - 3X spectral bands, 4x spatial resolution, and 5x temporal resolution
Much more imagery and much quicker to be used by Washington VAAC

Launch scheduled for mid October 2016

GOES-R – 16 channel Description

TABLE 1. Summary of the wavelengths, resolution, and sample use and heritage instrument(s) of the ABI bands. The minimum and maximum wavelength range represent the full width at half maximum (FWHM or 50%) points. [The Instantaneous Geometric Field Of View (IGFOV).]

Future GOES imager (ABI) band	Wavelength range (μm)	Central wavelength (μm)	Nominal subsatellite IGFOV (km)	Sample use	Heritage instrument(s)
1	0.45–0.49	0.47	1	Daytime aerosol over land, coastal water mapping	MODIS
2	0.59–0.69	0.64	0.5	Daytime clouds fog, insolation, winds	Current GOES imager/ sounder
3	0.846–0.885	0.865	1	Daytime vegetation/burn scar and aerosol over water, winds	VIIRS, spectrally modified AVHRR
4	1.371–1.386	1.378	2	Daytime cirrus cloud	VIIRS, MODIS
5	1.58–1.64	1.61	1	Daytime cloud-top phase and particle size, snow	VIIRS, spectrally modified AVHRR
6	2.225–2.275	2.25	2	Daytime land/cloud properties, particle size, vegetation, snow	VIIRS, similar to MODIS
7	3.80–4.00	3.90	2	Surface and cloud, fog at night, fire, winds	Current GOES imager
8	5.77–6.6	6.19	2	High-level atmospheric water vapor, winds, rainfall	Current GOES imager
9	6.75–7.15	6.95	2	Midlevel atmospheric water vapor, winds, rainfall	Current GOES sounder
10	7.24–7.44	7.34	2	Lower-level water vapor, winds, and SO_2	Spectrally modified current GOES sounder
11	8.3–8.7	8.5	2	Total water for stability, cloud phase, dust, SO_2 rainfall	MAS
12	9.42–9.8	9.61	2	Total ozone, turbulence, and winds	Spectrally modified current sounder
13	10.1–10.6	10.35	2	Surface and cloud	MAS
14	10.8–11.6	11.2	2	Imagery, SST, clouds, rainfall	Current GOES sounder
15	11.8–12.8	12.3	2	Total water, ash, and SST	Current GOES sounder
16	13.0–13.6	13.3	2	Air temperature, cloud heights and amounts	Current GOES sounder/ *GOES-12+* imager

Current channels

Source: Schmit, T.J., Gunshor, M.M., Menzel, W.P., Gurka, J.J., Li, J., Bachmeier, A.S., 2005, Introducing the Next-Generation Advanced Baseline Imager on GOES-R, Bulletin of the American Meteorological Society, v. 86, p. 1079-1096.

Future Opportunities and Challenges

Opportunities:

- Much better temporal resolution – Seeing eruptions much earlier
- Additional spectral channels – The ability to see volcanic ash and SO2 much easier and using RGBs to pick out volcanic ash during cloudy events.

Challenges

- When to advise and not to advise on a volcanic ash eruption - Our ability to see volcanic ash much more easily will provide a challenge to the volcanic ash analyst. Do we need to send out advisories for ash extending roughly 10-15 nm from the volcano when we know the protocol is too stay farther away from the volcano.

- Do we alert the MWO to send a NOTAM or a SIGMET in small eruption cases?

- How do we monitor – if imagery is ingesting every 5-10 minutes and possibly sooner in mesoscale scans (every 30 second/1 minute), will we be able to monitor such large areas as quickly and efficient as needed

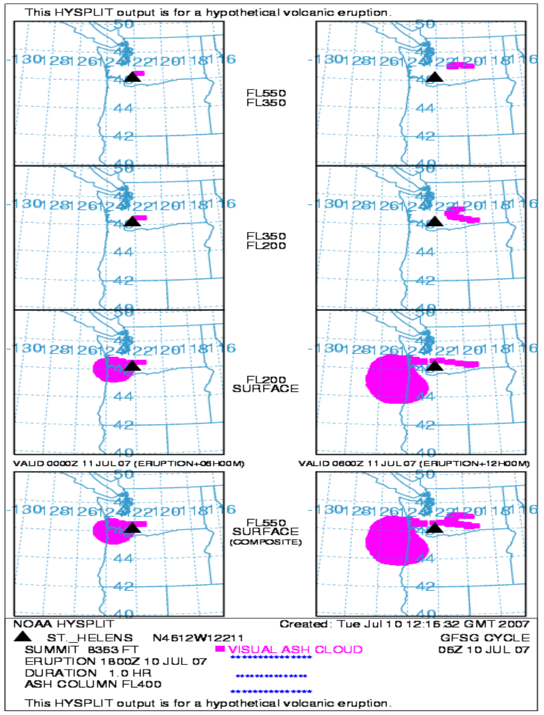
- Much more stuff to look at such as RGBs, new algorithm alerts, legacy products – how do we organize all this information in a timely manner.

Improving the Forecast with Additional Satellite Data

Information provided by the volcanic ash analyst to run a HYSPLIT:

- **Location of the volcano**
- **Eruption time**
- **Eruption duration**
- **Estimated height of volcanic ash**

What will be the effects of additional satellite imagery being ingested into the forecast model (input parameters)? Will we have better output for volcanic ash forecasting when the analyst runs it?



World demand for future advisory

Users needs for advisory < 1 >

- Information on ash density (concentration)

  Do aircrafts need to avoid the entire area? Can go through the edge of the area?

- Information how the advisory is reliable (how confident VAAC is)

How shall we meet the needs?

- concentration will be related to quantitative ash mass column loading

  → will have some information from a session on 21 October "Remote sensing and in situ sampling"

The effort will lead to creating criteria for volcanic ash impact to aircrafts

World demand for future advisory

Users needs for advisory < 2 >

- Information on SO_2 extent

  SO_2 is bad for health, especially for people who have asthma

  SO_2 smell is not pleasant for passengers

  SO_2 may be useful to grasp the status of volcano activity

How shall we observe and forecast SO_2?

- satellite can detect SO_2 extent (and density depending on a satellite)
- as for forecast SO_2 extent, diffusion model can simulate it
  (verification with observed data is necessary before operational use)

Further research is required to see what service is necessary, what can be achieved in future, etc.

Thank you

Tokyo and Washington VAAC