

“Thermal remote sensing for global volcano monitoring: Experiences from the MIROVA system”

APPENDIX

This document reports the surveys carried out by volcanological observatories and by institution in charge of volcano monitoring, in relation to the operational use of the MIROVA system.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Servicio Nacional de Geología y Minería (SERNAGEOMIN), Chile

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Country:	Chile
Role:	Research Scientist
Date:	November 5, 2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

Yes, but only as a complement of ground-based monitoring system, which is mostly based on a seismic network

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes, for both operational monitoring by the staff at the volcano observatory and directly for retrospective analysis if some eruptions

3. For which volcanoes do you use MIROVA data?

Volcano observatory uses MIROVA for all the 45 monitored volcanoes

4. During which eruptive crises did you use MIROVA data in real-time?

MIROVA is used in near real-time observation of ongoing crisis (volcanoes under orange or red alert level) by the volcano observatory

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

It depends on the alert level; sometimes daily, many times occasionally and in a regular basis (weekly or monthly) for all of the monitored volcanoes as part of the operational scheme at the volcano observatory

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Presence of anomalies at monitored volcanoes; intensities and trends in long-lived anomalies

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Monitoring and derived monitoring reports; sometimes for research of past events

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

Information about the thermal anomalies and their evolution over time, sometimes not accompanied by significant seismicity

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Ongoing crisis in Nevados de Chillán Volcanic Complex 2016-present; and Villarrica Volcano in recurrent periods

10. How could the system be improved?

Perhaps with better thresholds for the automatic detection; and better physical basis for some of the factors used in estimation of rates over time

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Perhaps in theory, although as far as I know this is not present in the short-term strategic planning and would require significant effort in terms of training and facilities

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Support is probably warranted as end-users while the system remain open and free.

13. Comments:

MIROVA and other platforms are good complement of the ground-based monitoring efforts; should be supported by the international community because they foster also the scientific research and provide large time series that improve our understanding of the eruptive processes.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Observatorio Volcanologico de Los Andes del Sur (OVDAS-SERNAGEOMIN), Chile

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Date:	23-10-2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

We don't have an own system. For monitoring we use the data from MIROVA and MODIS project.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes, we use MIROVA and MODIS daily.

3. For which volcanoes do you use MIROVA data?

All the volcanoes that MIROVA are processing.

4. During which eruptive crises did you use MIROVA data in real-time?

Villarrica (2015), Nevados de Chillan (since 2016).

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Daily

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Presence and absence of thermal anomalies, position of hotspots and distance from volcano.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Monitoring and Activity Reports.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

Principally, thermal anomalies that we could relate with seismical data and shallow activity

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Actually we use the data for Nevados de Chillan crisis.

10. How could the system be improved?

In our case, taking into consideration our current need, would include more volcanoes that are currently monitored by our observatory.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes, of course. Now we are interested in start a local system of satellite thermal monitoring and include all the monitored volcanoes (45) by OVDAS.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes, we are very interested.

13. Comments:

N/A

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Instituto Geofísico del Peru (IGP), Peru

Contact Person

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Country:	Perú
Role:	Analyst on Volcanology
Date:	3 August 2019

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

Yes, MIROVA system.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes, of course.

3. For which volcanoes do you use MIROVA data?

Ubinas, Sabancaya, Misti, Ticsani, Tutupaca, Yucamane, Huaynaputina, Sara Sara and finally, the Casiri volcano.

4. During which eruptive crises did you use MIROVA data in real-time?

In our observatory we use MIROVA system in Ubinas Volcano (2013-2017) even in the new eruptive process (2019). Another case is Sabancaya volcano (2016-2019).

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Daily.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

The intensity was very usefully to get a good job.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

The main use is the monitoring, initially with an internal discussion and then the making final report.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

The main information is verifying the domo formation in andesitic volcanoes like Ubinas and Sabancaya.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

We try to correlate the interdisciplinary data, it's include MIROVA system.

10. How could the system be improved?

The temporal resolution, it's an important improve.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes, it would.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes, of course.

13. Comments

The MIROVA system was very important in the evaluation of the eruptive process of the Ubinas volcano, especially in 2014, and in the Sabancaya volcano before its eruption at the end of 2016.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Instituto Geológico Minero y Metalúrgico (INGEMMET), Perú

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Date:	11/10/2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Si

3. For which volcanoes do you use MIROVA data?

Misti, Ubinas and Sabancaya

4. During which eruptive crises did you use MIROVA data in real-time?

Sabancaya (2016-2018)

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Daily

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Presence of thermal anomalies

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

All

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

Currently, we have thermometers on Sabancaya volcano, but just with internal registration. We do not have real time. Mirova generates information in real time.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

We use the Mirova information in our weekly discussions, before we make our reports.

10. How could the system be improved?

Sometimes Mirova confuses fires with volcanic thermal emissions.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes.

13. Comments:

The information from Mirova helps us to know more about our volcanoes. The thermal anomalies precede periods of explosions in the Sabancaya volcano.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Universidad Nacional de San Agustín de Arequipa (UNSA), Peru

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Role:	Principal Researcher
Date:	01-10-2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes, we currently use the MIROVA system

3. For which volcanoes do you use MIROVA data?

We use for all the volcanoes in Peru, but specially Sabancaya and Ubinas volcanoes which have been active in the last 25 years

4. During which eruptive crises did you use MIROVA data in real-time?

The Ubinas volcano erupted from 2013 to 2017, and the Sabancaya volcano is erupting since November 2016 until now. In both cases we used MIROVA data in real-time.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Daily.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Mainly and daily, we observe the presence/absence of thermal anomalies and its intensity.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Internal discussions and activity reports.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

We do not obtain any other information.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Before an eruption, every day we compare the seismic data with the state of MIROVA information.

When the eruption begins, we use the MIROVA intensity values to compare with other parameters as ash plume, SO₂ emissions, etc. Also every day we compare MIROVA with the state of seismicity. All these parameters are considered for to take, eventually, any recommendation of the population evacuation for civil protection authorities.

10. How could the system be improved?

If the system could arrive to give values of temperature at the crater, it could be interesting because frequently there is a slow increment of temperature when the magma influence approaches to surface.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

I am currently at the Universidad Nacional de San Agustín de Arequipa (UNSA) and yes, we are interested in developing a local system of satellite thermal monitoring. If Torino University could collaborate with UNSA it could be very interesting.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

I think it is possible; it could be done across an accord between universities.

13. Comments

The UNSA University is the largest national university in southern Peru. The faculty of Geology, Geophysics and Mining of this university is now increasingly committed to scientific research and volcano monitoring.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Instituto Geofísico-Escuela Politécnica Nacional (IGEPN), Ecuador

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Role:	Volcano Monitoring and Early Warning Alerts
Date:	22-OCTOBER-2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes

3. For which volcanoes do you use MIROVA data?

Antisana, Atacazo-Ninahuilca, Cerro Azul, Cayambe, Chacana, Chachimbiro, Chimborazo, Cotopaxi, Cuicocha, Fernandina, Guagua Pichincha, Iliniza, Imbabura, Licto, Mojanda, Sierra Negra, Pululahua, Quilotoa, Reventador, Sangay, Soche, Sumaco, Tungurahua, Wolf

4. During which eruptive crises did you use MIROVA data in real-time?

Reventador: 2014 – present
Tungurahua: 2014 – present
Sangay: 2014 – present
Wolf: 2015
Cotopaxi: 2015 - present
Cayambe: 2016 (Seismic unrest)
Cerro Azul: 2017 (Seismic and deformation unrest)
Fernandina: 2017
Fernandina: 2018
Sierra Negra: 2018

5. How frequently do you consult the MIROVA website? (occasionally, monthly, weekly daily)

Daily

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Presence / absence of thermal anomalies, position of hotspots, intensity, eruptive evolution

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Main use is for Monitoring

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

Eruptive activity follow up.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Beginning and end of eruption. Changes in the intensity, and location of the active vents.

10. How could the system be improved?

Maybe with a more frequent information of eruptive activity from other satellites.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes, especially in the case of very remote volcanoes where we lack monitoring equipment

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes

13. Comments:

During the last 5 years, we at the IG, have been using very extensively MIROVA system, especially in remote volcanoes (Galápagos, Sangay, ...), which have proved to be very useful as a remote sensing monitoring tool.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Servicio Geológico Colombiano (SGC), Colombia

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Role:	Volcanic Monitoring and Research Coordinator
Date:	19-mar-2019

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

SGC have consulted/used data of some satellite thermal anomaly web information systems in the last fifteen years, starting in 2004 consulting web services like the ASTER Image Database for Volcanoes by Japanese Geological Survey (<https://gbank.gsj.jp/vsldb/image/index-E.html>), where is possible to observe TIR and SWIR ASTER imagery; and MODVOLC system (<http://modis.higp.hawaii.edu/>), using MODIS imagery, similar to MIROVA but less sensitive; recently, MIROVA of course and NASA FIRMS system (<https://firms.modaps.eosdis.nasa.gov/>) using MODIS and VIIRS-best resolution imagery. Since 2015, SGC as part of the Japanese-Colombian cooperation program SATREPS, we are participating in the development, for Latin-American volcanoes, of a web system by Tokyo University for detection of thermal anomalies, based on MODIS imagery: REALVOLC - Central and South America (<http://vrsserv2.eri.u-tokyo.ac.jp/>), this system give us daily data (no triggers over a certain threshold).

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes (please, see the answer above to the 1st question).

3. For which volcanoes do you use MIROVA data?

Currently, according to the activity levels of Colombia volcanoes, mainly for Nevado del Ruiz Volcano (since 2015 showing thermal anomalies related to a lava dome extrusion process). Nowadays other active Colombian volcanoes have fumarolic activity (mainly Cumbal, Azufral, Galeras, Puracé and Nevado del Huila) but the thermal anomalies associated to their activity are low for the sensitivity of MODIS. However, MIROVA data showing absence of relevant thermal anomalies for these other volcanoes help us to build a base line thinking in future bigger activity.

4. During which eruptive crises did you use MIROVA data in real-time?

Nevado del Ruiz volcano activity, specially since 2015 (lava dome extrusion process). Additionally, MIROVA's absence of thermal anomalies detection have helped to discard possible surface activity associated to Galeras and Chiles-Cerro Negro volcanoes deep earthquakes activity in the last four years (2015 – 2019). As a special study case, we refer the Cumbal volcano activity in 2016-2017, registering a clear increment in seismicity associated to the fluids dynamics of the volcanic system, together with slight increments in the temperature of several fumarolic fields, registered only by ASTER TIR-bands imagery (90 meters per pixel). One kilometer per pixel MODIS imagery was no able to catch up this activity changes. (At the end of 2016, we comment this issue to Diego Coppola by email).

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

The MIROVA consults periodicity is made according to the volcanoes activity level: Right now, daily or several times per day for Nevado del Ruiz (indeed Manizales Observatory in its main Monitoring Room has displayed permanently a screen with the Nevado del Ruiz MIROVA information. Additionally, weekly/monthly consults for other Colombian active volcanoes.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

All of them, including Google Earth “heat” maps.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

All of them, starting with Near-Real Time monitoring.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

As you know, in general, remote sensing methods allow us the surveillance of volcanic phenomena avoiding the risks associated to the human direct exposition at volcanic activity, it is very difficult or impossible to go up to the volcano summit and to measure directly lava domes or fumaroles temperatures. Satellite thermal anomalies data, just like MIROVA info, give us the possibility to correlated it to the information from other volcano monitoring methodologies (seismology, deformation, geo-chemistry, etc.), enriching an integrated volcanic activity analysis and evaluation, tending to a build volcano behavior models and more appropriate activity diagnosis.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

In the case of Nevado del Ruiz volcano (2012 – 2018), specially since 2015, MIROVA's thermal anomalies data have matched very well with shallow seismicity increments (in this context mainly “drum beats” type earthquakes), ash emissions (seismically associated to volcanic tremor), large SO₂ fluxes, tiltmeters inflationary trends, etc. Biggest VRP values have been clearly associated to the magma ascent to shallower levels of the volcanic conduit and the surface magma extrusion process (lava dome emplacement at the inner part of crater).

10. How could the system be improved?

In order to take a better advantage of the MIROVA data, thinking in a more detailed following-up of thermal anomalies time-evolution, would be necessary have the possibility to download (in ASCII or Excel format) the VRP, distance to the source, etc., data.

Inclusion of more Colombian active volcanoes in the MIROVA volcano list (<https://www.sgc.gov.co/volcanes/index.html>).

Extend the MIROVA processing and database backwards to previous Colombian volcanoes eruptive periods (for instance, Nevado del Huila activity between 2007 and 2010; Galeras volcano activity between 2004 and 2010). (Related to this points “10.a” and “10.b”, please refers to the question 11’s answer).

In the future, the implementation of VRP measurements using MIR and TIR bands from other new satellite thermal sensors, with better temporal and/or spatial resolution, like VIIRS (375 m per pixel), Sentinel-3 (250 m per pixel) and ABI GOES-R (500 m per pixel).

Additionally, would be interesting try to estimate, to quantify and to graph (for instance using the own MODIS cloud cover fraction data), if a certain VRP data was associated to a clear sky or middle clear-sky MODIS “shot”.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Definitely, yes. Indeed, related to 10.a and 10.b points, if SGC (with the permission and technical support from MIROVA project) can in the future have some kind of mirror or local implementation of MIROVA processing facilities, we would be able to reprocess (according to Coppola et al., 2013 method) by ourself MODIS data for recent-past activity of main Colombian volcanoes (for instance, Nevado del Huila activity between 2007 and 2010 and Galeras volcano activity between 2004 and 2010).

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Of course yes, about some kind of specific “technical support” to you, if you require it, from our knowledge and experience related to volcanic thermal activity and/or remote sensing data analysis. We can provide us help too if you need “trial-users” in order to test future new or beta MIROVA functionalities.

A necessary question: “supporting” for you is related to budget contribution?

13. Comments:

From SGC we want to express our gratitude to MIROVA project & MIROVA work-group for yours great efforts in order to feed and maintain your web information system and share this very valuable thermal anomalies’ information, extremely useful for our own efforts to make an integrated diagnosis of the volcanic activity.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología (INSIVUMEH), Guatemala

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Role:	Vulcanologist
Date:	201319

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

MIROVA, has been the most used for thermal monitoring system, as well as a complement to seismic monitoring.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

The MIROVA system, has been the most used tool in the thermal monitoring of active volcanoes, which has allowed the analysis of eruption evolution

3. For which volcanoes do you use MIROVA data?

It is used in the 3 active volcanoes of Guatemala, which are Pacaya Volcano, Fuego Volcano and Santiaguito Volcano (known as Santa María).

4. During which eruptive crises did you use MIROVA data in real-time?

It has been used for being in real type, in several eruption crises in the volcanoes of Fuego, Pacaya, Santiaguito (Santa María). However, it must be taken into account that the volcanoes in Guatemala are very active, so MIROVA data is used daily to complement the monitoring.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Daily

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Mainly the monitoring of thermal anomalies increase, intensity. Position of critical points..

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

It is part of the monitoring, it allows correlation with other parameters such as Volcanic seismology, with this, discussions of volcanic behaviour are made and daily or special reports of volcanic activity are made, in normal times and in crisis.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ?(what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

It has been a tool that provides important information in real time, on changes in thermal anomalies, which is complemented by changes in the increase in seismic activity of active volcanoes in Guatemala.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

In the volcanoes of Guatemala, innumerable examples such as the eruptions of the Fuego volcano, in 2015, 2016, 2017, 2018, Pacaya volcano, Santiaguito volcano (Santa María) during the time.

10. How could the system be improved?

Improve automatic detection thresholds; if possible in the future implement a temperature value in the volcano crater

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Definitely, if we are interested

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Of course we would be in the best disposition.

13. Comments:

We want to express our gratitude to MIROVA and its working group, which is a very important tool for volcanic surveillance, we are in the best disposition to collaborate in every possible way.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Universidad de Colima (UCOL), Mexico

Contact Person

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Country:	Mexico
Role:	Member of Committee for Mitigation of Geological Hazards
Date:	17 March 2019

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes

3. For which volcanoes do you use MIROVA data?

Volcán de Colima

4. During which eruptive crises did you use MIROVA data in real-time?

2015- 2017

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Weekly

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Presence of anomalies and the trend of temperatures

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

They are used for monitoring, added to reports of activity

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

It is impossible to conduct many flights for observation within the crater so MIROVA data is useful to get a longer time series

9. Describe an example of MIROVA's operational use during an eruptive crisis:

The time series of MIROVA data for Volcán de Colima is discussed and compared with other observations

10. How could the system be improved?

N/A

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Certainly

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Certainly

13. Comments:

N/A

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Koninklijk Nederlands Meteorologisch Instituut (KNMI), Netherlands

Contact Person

Name:	Elske de Zeeuw van Dalfsen
Email address:	Dalfsen@knmi.nl
Institution:	KNMI
Country:	Netherlands
Role:	Senior Research Scientist
Date:	11/10/2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes

3. For which volcanoes do you use MIROVA data?

Saba (Mnt Scenery)

4. During which eruptive crises did you use MIROVA data in real-time?

N/A

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Weekly

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Absence of thermal anomalies

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Monitoring, but also to contribute to activity reports/research if applicable.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

Changes in state of activity of the volcano, network is small (3 seismometers, 1 GNSS). Local population claims part of the volcano loses vegetation. This could be caused by volcanic activity.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

N/A

10. How could the system be improved?

Can not say, Saba was just added upon my request

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes, but as I am the only person responsible for two Caribbean volcanoes at the moment this would add to my workload. MIROVA therefor helps me tremendously.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data).

I could try and bring this under the attention of the institute, but it would not be my decision to make. Off course this would apply more to volcanoes that are more active than Saba.

13. Comments:

N/A

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Icelandic Meteorological Office (IMO), Iceland

Contact Person

Name:	Sara Barsotti
Email address:	sara@vedur.is
Institution:	Icelandic Meteorological Office
Country:	Iceland
Role:	Coordinator for volcanic hazards
Date:	15.03.2019

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

We do not have a system developed by us. We use systems developed by others and public.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

MIROVA has been used operationally during the Bárðarbunga volcano eruption in 2014-2015. Since then eight volcanoes in Iceland are regularly monitored through Mirova.

3. For which volcanoes do you use MIROVA data?

They are: Katla, Krafla, Krýsuvík, Reykjanes, Hekla, Grímsvötn, Öræfajökull, Bárðarbunga, Eyjafjallajökull and Askja

4. During which eruptive crises did you use MIROVA data in real-time?

For the Holuhraun eruption in 2014-2015

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Monthly

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

During the eruption we looked into all parameters, to understand the level of activity at the eruption site. In quiet time we mainly search for presence/absence of thermal anomalies

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

The monitoring is the main purpose. During the eruption in 2014-2015 the Mirova data were occasionally included in the Activity report (mainly toward the end of the eruption). During the Aristotle project (2017-2018) Mirova has also been used by IMO to follow the activity at volcanoes around the world and report on their activity level.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

Mirova is the only NRT system for thermal anomaly detection that IMO has included in its routinely checks. During the eruption the remote sensing techniques allowed access to information about the eruption even when the daylight time was reduced and the area not easily accessible for field trips due to winter conditions.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

During the Holuhraun eruption 2014-2015 Mirova has been regularly checked to monitor the level of activity at the eruption site, estimate of lava discharge rate and, eventually, to declare the end of the eruption. The data and results were often presented at the Scientific Advisory Board in presence of the Icelandic Civil Protection.

10. How could the system be improved?

In Iceland there are plenty of geothermal areas where the activity is generally very variable, I always wonder if Mirova could be extended to be sensitive enough to changes in T as experienced in these places, and secondly if Mirova could ever be possibly used for the detection of submarine eruptions.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

At IMO we have a small group of scientists looking into the satellite images processing, so it would be interesting to investigate this possibility also for this type of satellite thermal images.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Of course yes, and of course it would depend on the level of commitment required from our institution. I believe we should definitely look into some project initiatives that would support this implementation and extension.

13. Comments:

As already said the tool is very powerful and needed during the eruption time. It would be a great addition if its use could be extended to a more routine work of monitoring the status of volcanic/geothermal areas (but not necessarily eruptions). Mirova has been essential during the management of the Holuhraun eruption. Thank you!

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Institut de Physique du Globe de Paris (IPGP), Observatoire Volcanologique du Piton de la Fournaise (OVPF), La Réunion, France

Contact Person

Name:	AlinePeltier
Email address:	peltier@ipgp.fr
Institution:	Institut de Physique du Globe de Paris
Country:	France
Role:	Director of the Piton de la Fournaise volcanological observatory
Date:	9 octobre 2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

YES

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

YES

3. For which volcanoes do you use MIROVA data?

Piton de la Fournaise

4. During which eruptive crises did you use MIROVA data in real-time?

Not sure, maybe since a long-time even before I am in charge of the observatory ... systematically on the website for each eruption since June 2014.

5. How frequently do you consult the MIROVA website ?(occasionally, monthly, weekly daily)

During eruptive periods, almost daily, just before to write the daily report. It is also use for lava flow budget at the end of each eruption in order to compare with INSAR, insitu and SFM measurements. And it is also include in research activity of the team (Geophysics and Geochemistry).

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

Intensity, trend, lava flux

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Activity reports

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

It is a complementary data to estimate lava flux in surface. At the observatory we estimated these lava flux thanks to SO₂ flux and DEM's differences... it is thus very complementary of what we do at the observatory when we cannot take pictures to make DEM.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Piton de la Fournaise has a large monitoring network. An eruption is thus very well anticipated and the opening of the fissures very well recorded by Geophysical and Geochemicals in-situ real-time measurements, but also by observations (cameras and observers). Thus, Mirova does not have a role in diagnosing the occurrence of an eruption.

But, for operational surveillance, Mirova is used at the beginning of eruption to: have knowledge of the rate flow in order to compare this variable with the gas flux, the deformation rate, the energy of the tremor and the height of the lava fountains, analyze rate flow variations (relative analysis more than absolute),

- analyze the balance of the extruded material,
- map (at low resolution) the lava flow emplacement with the thermal image in order to obtain a position of the flow front.

10. How could the system be improved?

N/A

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

NO, because we already work with the MIROVA and HOTVOLC platforms. And we have no specific staff for this kind of development.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

YES if the service remains free.

VIIRS -> YES

Landsat 8 -> YES

Sentinel -> not sure, for us possible overlap with Casoar

13. Comments:

N/A

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Goma Volcano Observatory (GVO), Democratic Republic of Congo

Contact Person

Name:	KASEREKA MAHINDA CELESTIN
Email address:	mahindageophys@gmail.com
Institution:	GOMA VOLCANO OBSERVATORY (GVO)
Country:	DEMOCRATIC REPUBLIC OF CONGO (DRC)
Role:	SCIENTIFIC DIRECTOR OF GVO
Date:	16 MARCH 2019

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

No

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes, we use only MIROVA system

3. For which volcanoes do you use MIROVA data?

NYIRAGONGO, NYAMULAGIRA and MAYI YA MOTO HOT SPRING

4. During which eruptive crises did you use MIROVA data in real-time?

ACTUALLY THE TWO VOLCANOES (NYAMULAGIRA AND NYIRAGONGO VOLCANOES) HAVE A PERMANENT LAVA LAKE.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

DAILY

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

PRESENCE OF THERMAL ANOMALIES (VOLCANIC RADIATIVE POWER “VRP”)

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

MONITORING AND RESEARCH

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

NYIRAGONGO AND NYAMULAGIRA ACTIVE VOLCANOES ARE LOCATED IN THE VIRUNGA NATIONAL PARK (15 TO 32 KILOMETERS FROM THE GVO) SO IT IS NOT POSSIBLE FOR US TO ACCESS DAILY TO THIS VOLCANOES. MIROVA DATA CAN HELP US TO KNOW THE ACTIVITY OF THE VOLCAOES WHEN THE

SOME EQUIPMENTS ARE NOT WELL RUNNING LOOKING ON THE MIROVA DATA WE CAN PLAN FOR A FIELD WORK ON THE SUMMIT OF THE VOLCANOES

9. Describe an example of MIROVA's operational use during an eruptive crisis:

FOR EXAMPLE DURING THE OCCURRENCE OF THE NEW SPATT CONE ON FEBRUARY 29, 2016 INSIDE THE NYIRAGONGO CARTER, WE COULD GET SOME INFORMATIONS ON THIS PARTICULAR SITUATION

10. How could the system be improved?

IMPROVE THE RESOLUTION OF MIROVA OBSERVATIONS LESS 1 KM GET IMMEDIATELY THE DISTANCE ANOMALIES (RADIUS) MEASUREMENTS FROM THE VOLCANOES CRATER. IN CASE SOLIDIFIED LAVA COVERS THE LAVA LAKE , WE DON'T KNOW HOW THE SYSTEM CAN OPERATE. THIS WAS THE SITUATION OF THE NYIRAGONGO BEFORE IT'S JANUARY 2002 ERUPTION

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

YES

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

GOOD IDEAS BUT OUR INSTITUTION BUDGET IS VERY POOR. NO FINANCIAL SUPPORT FROM THE GOVERNMENT

13. Comments:

THANKS FOR YOUR QUESTIONNAIRE. IT HELPED US A LOT TO REVIEW WHAT WE ALREADY THROUGH MIROVA TO GET AT "GVO" THE MIROVA DATA IN REAL TIME REMAINS A STRONG NEED. BUILDING CAPACITY IN PROCESSING MIROVA DATA REMAINS ALSO OUR DEMAND.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

US Geological Survey – Volcano Disaster Assistance Program (VDAP), USA

Contact Person

Name:	Julia Griswold
Email address:	griswold@usgs.gov
Institution:	US Geological Survey – Volcano Disaster Assistance Program (VDAP)
Country:	United States of America
Role:	Geologist
Date:	April 2, 2019

1. Does your Institute have/use an automatic system of satellite thermal monitoring of volcanoes under observation?

I routinely scan a list of volcanoes of concern using either the MIROVA or MODVOLC websites, especially since the Aster Volcano Archive recent thermal anomaly list no longer operates. I can on occasion get ASTER thermal data ordered for a single volcano through colleagues' access, but this is not always reliable and not possible for a complete list of volcanoes that are of concern at any given time. NIR, SWIR, TIR bands from any of Sentinel, Landsat and WorldView are also useful when trying to evaluate for heat at the surface or near surface.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes. Daily to weekly.

3. For which volcanoes do you use MIROVA data?

VDAP regularly monitors active volcanoes that are at unrest or a state of eruption in developing countries in Latin America, SE Asia-Pacific, and Africa where we have established relationships of support through partner request or invitation.

4. During which eruptive crises did you use MIROVA data in real-time?

Many. Recently these volcanoes might include Agung, Fuego, Pacaya, Nevados de Chillan, Popocatepetl, Sinabung, Karangetang, Krakatau, Nyiragongo and Nyamaguirra, Manam, Ibu, Masaya, Momotombo, Sabancaya, Rabaul, Nevado del Ruiz, Mayon etc. etc. etc.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

Weekly to daily.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

I use MIROVA as a rapid way to maintain situational awareness. In conjunction with seismic, gas geochemistry, visual change, deformation data, MIROVA provides an initial check for activity intensity at volcanoes where lava flows or domes or simply hot, degassing open vents. Being able to track relative changes in thermal output (Watts) as a time series provides a minimum assessment of change although lack of thermal data never necessarily means a volcano is cooling off, just that there are clouds or thick ash clouds present. It's also a useful tool to scan for lava flows issuing from more distal flank fissures, although naturally, there are many false positives. The website provides a very useful way to quickly discern this information. While it is fairly easy to assess false positives for flank eruptions vs. fires, it would be nice to have a cursory way to evaluate for cloudiness that minimizes thermal detection.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

Activity reports and situational awareness. We also include use of the website at trainings offered at volcano observatories where they are just starting to use remote sensing as part of their volcano monitoring. The MIROVA website is very accessible to observers who don't necessarily have the background or funding support for more elaborate remote sensing analysis. Furthermore, the website is reliable, immediately accessible and requires no maintenance on their part beyond reliable internet.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

Within limits, the distribution of the thermal feature allows for an assessment of stable versus collapsing dome growth by whether the hot pixels are clustered tightly at the summit or aligned with a channel down the flank which might suggest dome collapse rock falls or pyroclastic density currents or a lava flow. In the case of hot pixels down a channel, the sector and distance of furthest pixels provides a quick estimate for hazardous areas that ought to be maintained as part of an exclusion zone. e.g. Manam, Karangetang, Sinabung. This becomes critical as eruption duration spans years and societal pressures on local officials to re-open evacuated areas increases.

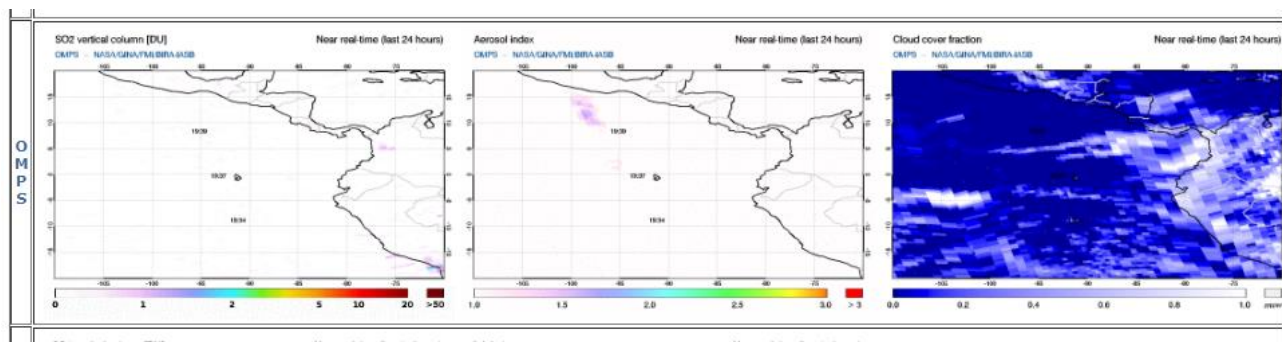
9. Describe an example of MIROVA's operational use during an eruptive crisis:

At Momotombo where lava flowed down the flank during a recent eruption, it appeared like the eruption might be over and that the optically black lava had cooled, but thermal data showed that it was decidedly still hot near the summit and along the flow. This information in conjunction with seismic activity, meant that the lava might still be feeding the flow internally or that the potential for lava flow front/ perimeter collapse or additional activity from the summit persisted.

10. How could the system be improved?

I really appreciate how useful this website is. If you were looking for ways to make improvements, my suggestion might be to include an evaluation for cloudiness or try to answer the question of how obscured might thermal detection be (or a minimum threshold for how hot a pixel would have to be to detect heat through today's clouds).

The [SACS.aeronomie.be/nrt/](https://sacs.aeronomie.be/nrt/) website provides a rudimentary check on cloudiness (right panel) when evaluating SO₂ and aerosol presence [screenshot here of OMPS].



I would also love to see an added ability to review this analysis beyond the 10 most recent scenes (typically past 3 days). The time series plots of Watts and distance are incredibly useful, but sometimes you just want to see the image to get the full sense for the spatial pattern. MODVOLC offers an efficient ability to go back days, months, years and still get a quick plot of the distribution of thermal alerts. MODVOLC also offers the ability to get pixel radiance in a list for all those alert pixels which is a nice feature. The two websites complement each other nicely. I tend to rely on MIROVA for current situation information because the graphic display is so intuitively easy to use, but need to rely on MODVOLC for anything beyond past 3 days. It would be nice to have the MIROVA data display saved to an archive.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Possibly. Or, an international partner in a regional observatory might. It depends on the added work load required. Observatory staffing around the world varies considerably so some might be very interested and others are already too overwhelmed. Some countries where volcanoes are numerous and remote or logistically challenging to get to might greatly desire this in-house processing (e.g. perhaps Chile, Argentina, Peru). However, having this information already processed automatically in a reliable, central location is a huge public service!

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

This effort would be tremendous!

13. Comments:

I really appreciate the responsiveness of Diego and the MIROVA team to adapt and add new targets to the website quickly at request. I wrote to Diego when Agung started erupting that while Agung showed up in the corner of the Batur dataframe, it would be useful to have an area centred on Agung also. Many thanks!

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Geological Agency of Indonesia–Center for Volcanology and Geological Hazard Mitigation (CVGHM), Indonesia

Contact Person

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Email address:	toryhebat@gmail.com , oktory.prambada@mail.esdm.go.id
Institution:	Geological Agency of Indonesia–Center for Volcanology and Geological Hazard Mitigation
Country:	Indonesia
Role:	Technical staff of volcano monitoring and research division
Date:	October 12 th , 2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

Not yet realize, we still do manual volcano thermal monitoring

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

We always use MIROVA system in our evaluation report of volcanoes in Indonesia

3. For which volcanoes do you use MIROVA data?

Sinabung, Ijen, Raung, Agung, Batur, Rinjani, Sangeangapi, Tambora, Lokon, Soputan, Karangetang, Awu, Gamalama, Dukono, Ibu, Rokatenda, and every volcano that has the risen of activity (we monitoring at least 66 “Type A” volcano in Indonesia from total 129 volcanoes)

4. During which eruptive crises did you use MIROVA data in real-time?

Off course we did..!

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

we are using MIROVA website every day for highest level activity, twice in a week for level 3 activity, and monthly for normal activity volcanoes

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend).

Graphic of thermal anomalies, intensity, and position of hotspots (We hope for a better resolution for position of hotspots.

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research).

For Monitoring, Internal discussion and activity reports

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ? (what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide).

Better resolution map of the volcano

9. Describe an example of MIROVA's operational use during an eruptive crisis:

During Agung crisis and Rinjani crisis, MIROVA is a must available parameter for internal discussion before make a decision for a activity status of the volcanoes.

10. How could the system be improved?

We will be happy if there are any downloadable raw file of presence of anomalies, and intensities data.

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network).

We are very interesting to developing a local system in CVGHM off course.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data).

We are encourage to supporting an update version for MIROVA

13. Comments:

Good Job for now for MIROVA's team.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Rabaul Volcano Observatory (RVO), Papua New Guinea

Contact Person

Name:	Steve Saunders
Email address:	Steve_saunders@mineral.gov.pg
Institution:	Rabaul Volcano Observatory
Country:	Papua New Guinea
Role:	Principal Geodetic Surveyor
Date:	10/10/2018

1. Does your Institute has/uses an automatic system of satellite thermal monitoring of volcanoes under observation?

NO

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

YES

3. For which volcanoes do you use MIROVA data?

BAGANA, KADOVAR, KARKAR, LANGILA, MANAM, PAGO, RABAU, ULAWUN

4. During which eruptive crises did you use MIROVA data in real-time?

As close to 'real-time' as the data frequency allows. MANAM, KADOVAR, BAGANA and in responding to concerns at others.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

At least daily. Hourly during crisis. Also an in-house developed script takes a screen grab of the website every 3 hours and automatically displays it in the data acquisition room; if internet access is available.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

all of these

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

routine monitoring, verifying reports or rumours, internal and wider discussions, activity reports. Patterns seen in monitoring could be said to be on-going 'research'.

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring ?(what kind of volcanological information you may obtain from space-base thermal data that your current network is not able to provide)

Firstly, it provides support to our other monitored parameters. Secondly, it provides invaluable information for volcanoes we do not monitor in other ways.

9. Describe an example of MIROVA's operational use during an eruptive crisis: -

In the recent Manam eruption it provided confirmation that increased RSAM was due to renewed activity and that the activity involved 'flows', and in what direction the flows were moving. The waning of the activity was also observable.

10. How could the system be improved?

More satellites to get more regular observations! (I know it is beyond your powers). Would it be possible to have the PNG area on the pop-up map, without scrolling?

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes, if infrastructure and other resources permitted. question is what would be the minimum requirements to do this?

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes as long as there is no increase in the bandwidth too access the basic practical data etc. What is meant by supporting? (Enthusiasm or funds?), we have an abundance of the former but are lacking in the latter.

13. Comments:

It is now an integral part of our routine monitoring. Has been of great help, now one of the pillars of monitoring remote volcanoes.

Diego's proactiveness in adding Kadovar and Karkar as crisis's and rumours developed was most appreciated, thank you. We will discuss and perhaps ask for a couple more to be added in future.

MIROVA SURVEY

Use of the MIROVA system by Volcanological Observatories and Institutes in charge of volcano monitoring and reporting:

Vanuatu Meteorology and Geohazards Department (VMGD), Vanuatu

Contact Person

Name:	Ricardo William and Sandrine Cevuard
Email address:	rwilliam@vanuatu.gov.vu ; scevuard@vanuatu.gov.vu ;
Institution:	Vanuatu Meteorology and Geohazards Departmen
Country:	Vanuatu
Role:	Scientific Officer Geochemist; Scientific Officer Volcano Seismology
Date:	2019.03.19

1. Does your Institute have/use an automatic system of satellite thermal monitoring of volcanoes under observation?

Yes our institute have used automatic system of satellite thermal monitoring of volcanoes.

2. Do you use or have you used the MIROVA system (or others) for satellite thermal monitoring of volcanoes?

Yes we do used MIROVA and Modvolc.

3. For which volcanoes do you use MIROVA data?

For all Vanuatu Volcanoes (Gaua, Ambae, Ambrym, Lopevi and Yasur).

4. During which eruptive crises did you use MIROVA data in real-time?

We used Mirova during Ambae eruption in 2017-2018 and Ambrym eruption 2018.

5. How frequently do you consult the MIROVA website ? (occasionally, monthly, weekly daily)

We occasionally consult the MIROVA website.

6. What information useful for monitoring did you get from the MIROVA system? (presence / absence of thermal anomalies, position of hotspots, intensity, trend)

The main useful information that we get from the MIROVA system are:

- Presence and absence of thermal anomalies
- Intensity
- Trend
- Its distance from volcanic summit

7. What is the main use of the observations / images / data obtained from MIROVA? (Monitoring, internal discussions, Activity Reports, Research)

The main use of the observations / images / data obtained from MIROVA are:

- Monitoring

- Forecast eruption
- Internal discussions and activity reports

8. Within the framework of your local volcano surveillance network, what is the added value of the satellite thermal data to the daily monitoring? (what kind of volcanological information you may obtain from space-based thermal data that your current network is not able to provide)

The additional information that the thermal data provided to our network is on the daily thermal anomalies intensity and trend that can help us to know about the rate of the volcano activity at the summit and also areas around the volcano. Moreover, this thermal data let us know about the possible obvious lava at the volcano summit.

9. Describe an example of MIROVA's operational use during an eruptive crisis:

Daily use of MIROVA can help to estimate the volcano eruptive phase such as during the Ambae eruptive phase in July 2018.

10. How could the system be improved?

The system can be improved:

- Simple display of the daily, monthly and annual value – that can be save easily for archived by volcano observatories for future purposes;
- Thermal data archive on line in the website especially for the post event;
- Occasional false thermal reading and notification;

11. Would your institution be interested in developing a local system of satellite thermal monitoring? (Download, processing, analysis, visualization and data dissemination on local network)

Yes we do.

12. Would your institution be interested in supporting an updated version of MIROVA? (Data and images downloadable in real time, added VIIRS data, added Landsat 8 and Sentinel S2 data)

Yes we do.

13. Comments:

MIROVA is a:

- Valuable open data source, accurate and reliable for volcano monitoring specifically in thermal anomalies;
- The extracted information from the website help to complete the geochemistry information from our volcano monitoring system;
- Available data in real time;
- Friendly and quick response from our queries;