



MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Natural Hazards in Brazil – Challenges and helpful tools

Lincoln Muniz Alves, Laercio Namikawa, Eymar Lopes
INPE/CGCP/DIIAV
lincoln.alves@inpe.br



MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO



Introduction



Credit: Minas Gerais Civil Defense



[Credit: Yoda Adaman | Unsplash]

“It is indisputable that human activities are causing climate change, making extreme climate events, including heat waves, heavy rainfall, and droughts, more frequent and severe”

“Climate change is already affecting every region on Earth, in multiple ways. The changes we experience will increase with further warming.”



MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO



Introduction



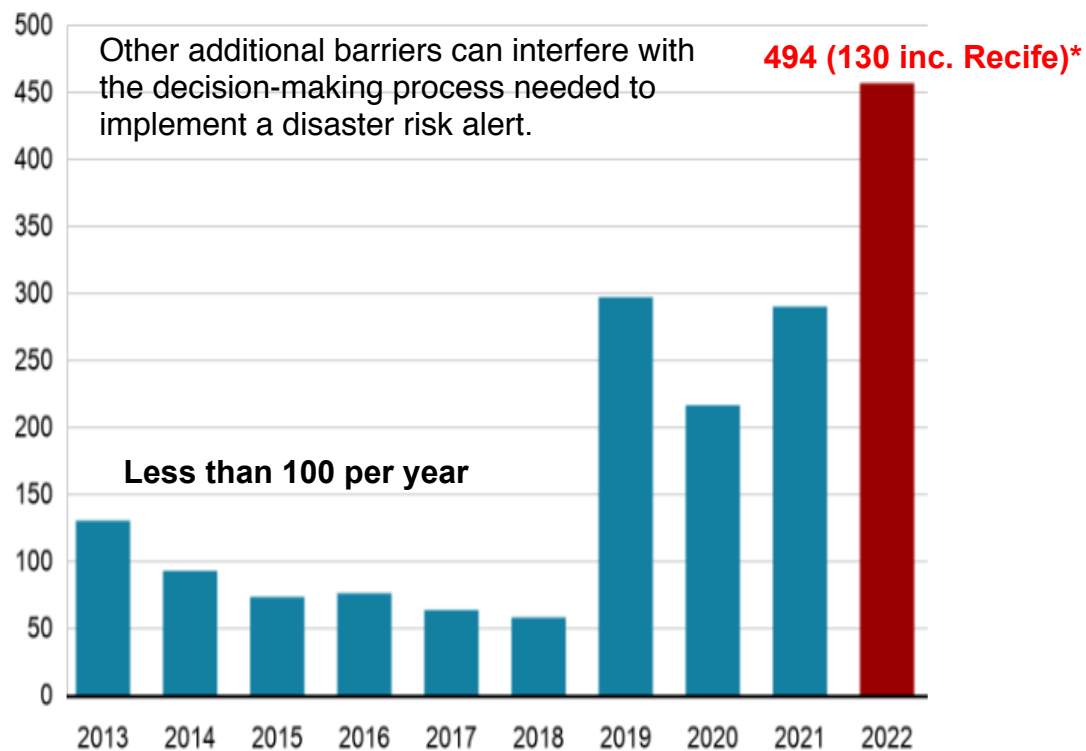
Photo: Amazon satellite

The focus of this presentation is to discuss how INPE is utilizing space data and technology, specifically through the platforms TerraMA2 and AdaptaBrasil, to address Brazil's unique environmental challenges, mitigate natural disasters, and inform public policy for climate adaptation.

The scale of the problem in Brazil



Number of deads consequence of disasters triggered by heavy rainfall in Brazil



Fonte: Confederação Nacional dos Municípios / Defesas Cívicas
BBC

BBC



MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO



São Paulo, Brazil – February/2023



On February 18th-19th, 2023, heavy rainfall of 680 mm in less than 24 hours triggered multiple fatal and flash floods landslides in the city.

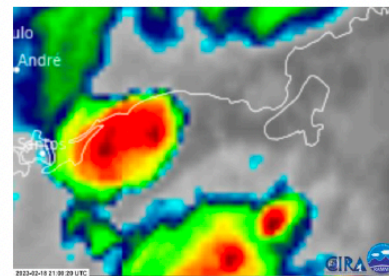
This is the highest rainfall in all of Brazil in modern history.

This trigger water-saturated soil led to deadly floods, debris flow, and landslides resulting in 65 casualties and damages.

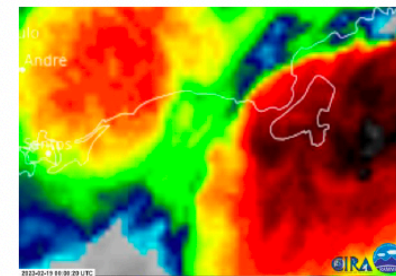


São Paulo, Brazil – February/2023

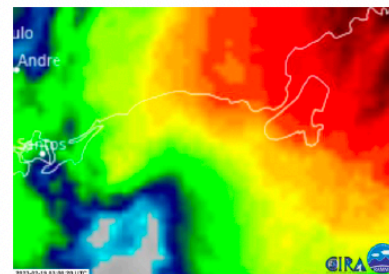
GOES-16 IR satellite images,
with 6-hours interval, from 2100
UTC on 18 February to 12:00
UTC of 19 February. Fonte:
Colorado State University -
[https://rammb-
slider.cira.colostate.edu/](https://rammb-slider.cira.colostate.edu/)



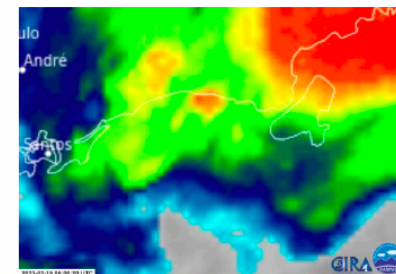
A) 2023-02-18 21:00 UTC



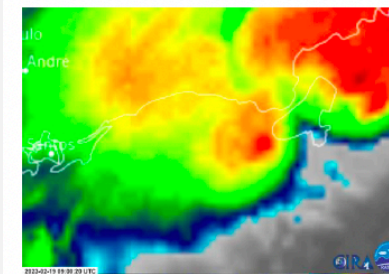
B) 2023-02-19 00:00 UTC



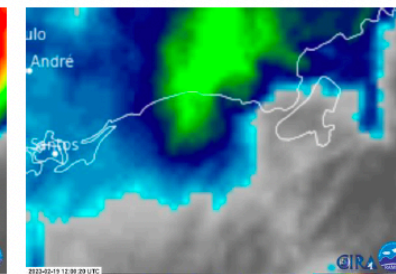
C) 2023-02-19 03:00 UTC



D) 2023-02-19 06:00 UTC



E) 2023-02-19 09:00 UTC



F) 2023-02-19 12:00 UTC

World Records

https://www.weather.gov/owp/hdsc_world_record

Duration	Amount (mm)	(in)	Location	Lat (deg)	Long (deg)	Start date
1-minute	**38	**1.50	Barot, Guadeloupe, West Indies	16.25	-61.45	26 Nov 1970
	31	1.23	Unionville, Maryland, USA	39.45	-77.18	4 Jul 1956
5-minute	63	2.48	Porto Bello, Panama	9.55	-79.65	29 Nov 1911
8-minute	126	4.96	Fussen, Bavaria, Germany	47.87	12.17	25 May 1920
15-minute	198	7.80	Plumb Point, Jamaica	17.93	-76.78	12 May 1916
20-minute	206	8.11	Curtea de Arges, Romania	45.12	24.42	7 Jul 1889
30-minute	280	11.0	Sikeshugou, Hebei, China	41.78	117.93	3 Jul 1974
42-minute	305	12.0	Holt, Missouri, USA	39.45	-94.33	22 Jun 1947
60-minute	*401	*15.8	Shangdi, Inner Mongolia, China	42.27	119.13	3 Jul 1975
	381	15.0	Smethport, Pennsylvania, USA	41.87	-78.34	18 Jul 1942
	305	12.0	Holt, Missouri, USA	39.45	-94.33	22 Jun 1947
	305	12.0	Kilauea Plantation, Kauai, Hawaii, USA	22.21	-159.41	24 Jan 1956
72-minute	440	17.3	Gaoj, Gansu, China	34.85	104.67	12 Aug 1985
2-hour	489	19.3	Yujiawanzi, Inner Mongolia, China	41.50	118.93	19 Jul 1975
2.5-hour	550	21.7	Bainaobao, Hebei, China	41.58	114.30	25 Jun 1972
2.75-hour	559	22.0	Woodward Ranch (D'Hanis 17 NNW), Texas, USA	29.49	-99.38	31 May 1935
3-hour	600	23.6	Duanjiazhuang, Hebei, China	40.33	114.58	28 June 1973
6-hour	830	32.7	Linzhuang, Henan, China	33.05	113.65	7 Aug 1975
8-hour	1050	41.3	Muduchaideng, Inner Mongolia, China	38.88	109.50	1 Aug 1977
10-hour	*1400	*55.1	Muduchaideng, Inner Mongolia, China	38.88	109.50	1 Aug 1977
12-hour	*1400	*55.1	Muduchaideng, Inner Mongolia, China	38.88	109.50	1 Aug 1977
	1144	45.0	Foc-Foc, Réunion Island	-21.23	55.68	7 Jan 1966



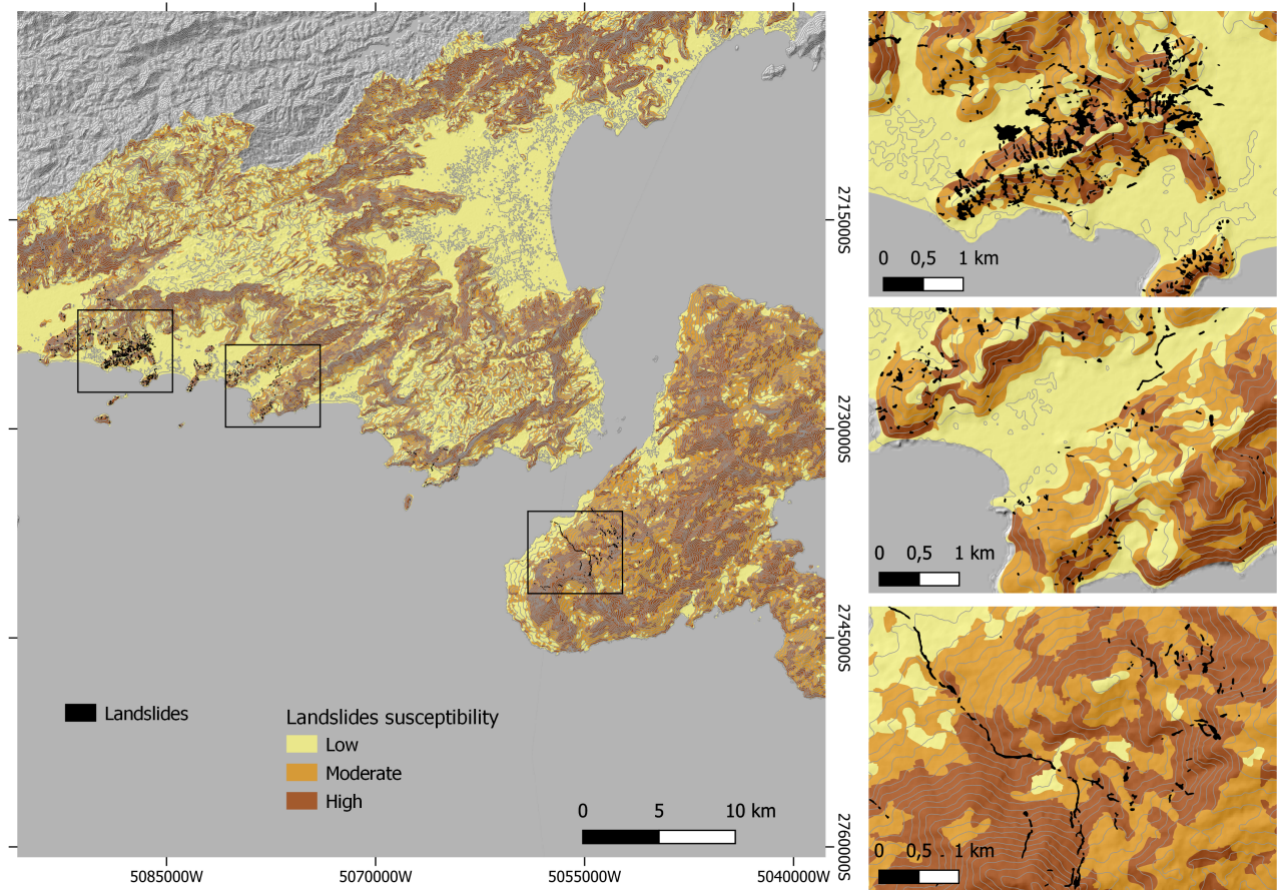
E INOVAÇÃO



UNIÃO E RECONSTRUÇÃO

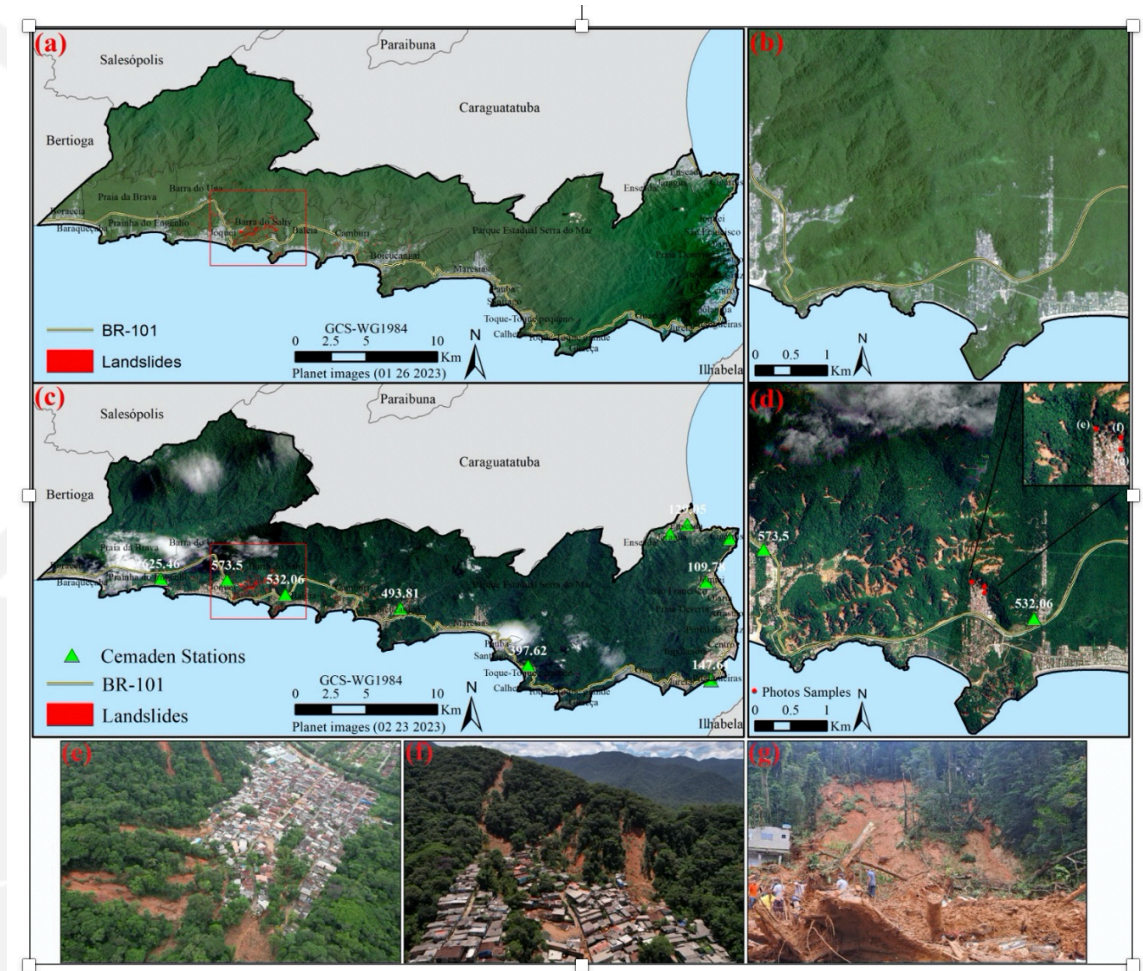
São Paulo, Brazil – February/2023

Susceptibility to landslides in São Sebastião and Ilhabela and scars from landslides triggered during the February 18th and 19th, 2023 event, in São Paulo North Coast. Landslides were mapped from satellite images provided by Rede MAIS/MJSP (including material © 2023 Planet Labs Inc.). Susceptibility map source: CPRM/IPT (2017).



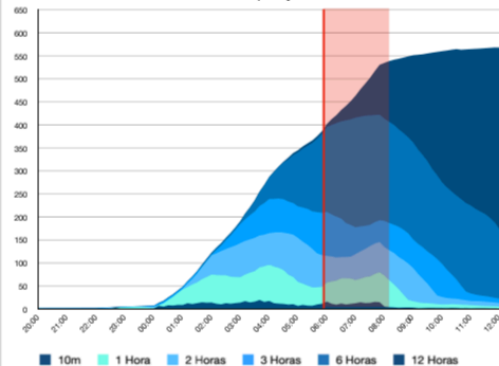
São Paulo, Brazil – February/2023

PlanetScope satellite image showing before the disaster (a), with a zoom in Barra do Sahy (b) and after (c,d). Figures (e, f and g) shows photos in Barra do Sahy after the landslides. The locations of each photo can be seen in figure (d).



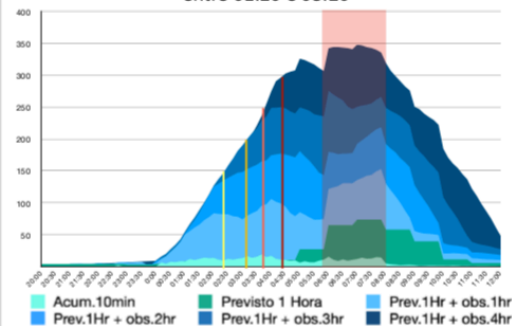
São Paulo, Brazil – February/2023

Juquehy2



Hora UTC	10 min	1	2	3	6	12
06:00	15,34	56,75	114,87	210,74	395,32	401,23

Acumulados em 1 Hora acima de 50 mm entre 01:20 e 08:20



Acum. em	Alerta Acumulado acima de ... (mm)	150	200	250	300
2 horas	07:50	-	-	-	-
3 horas	03:10	07:20	-	-	-
4 horas	02:30	03:10	06:00*	-	-
5 horas	02:30	03:20	03:50	04:20	-

*249 às 04:00

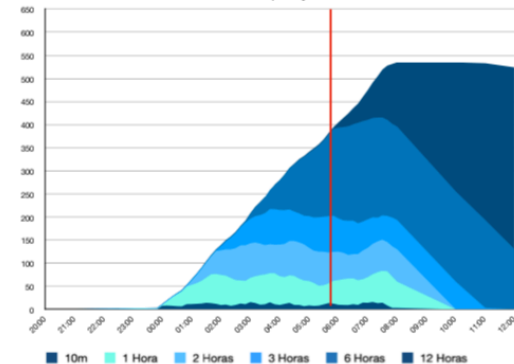
CORREIO DO POVO

ter contato com ela (a irmã) às 4 horas." As duas irmãs ainda esperam notícias da mãe, que mora na vila da Baleia e se encontrava incomunicável desde sábado.

A moradora e líder comunitária de Barra do Sahy Nalda Araújo também relatou momentos de terror e dezenas de casas soterradas. "Era por volta das 3 horas quando a gente ouviu uma gritaria. Saímos na rua e o pessoal disse 'Corre que o morro está desabando'. Eu moro a mais de 100 metros, mas, quando olhei para trás, o morro estava descendo com casa, carro, pessoas."

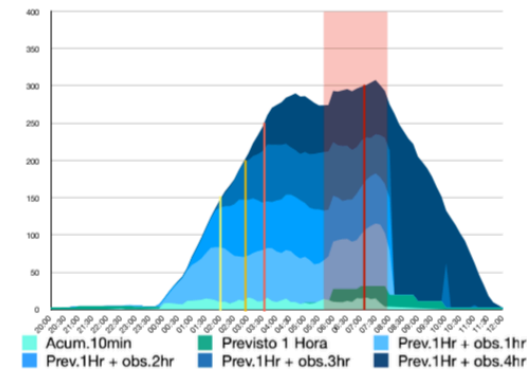


Juquehy



Hora UTC	10 min	1	2	3	6	12
06:00	10,17	63,62	125,2	197,3	393,76	404,82

Acumulados em 1 Hora acima de 50 mm entre 01:00 e 08:00

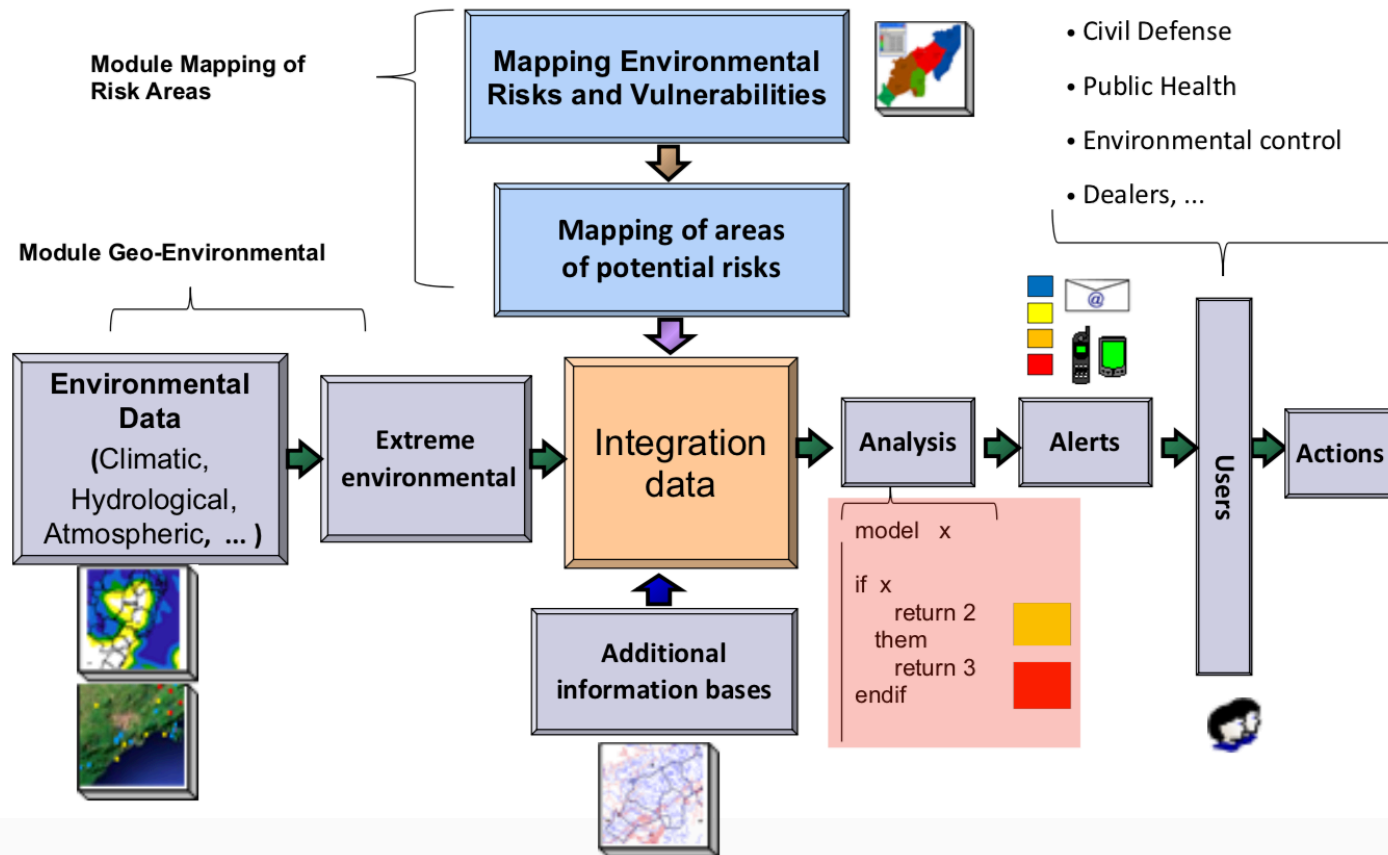


Acum. em	Alerta Acumulado acima de ... (mm)	150	200	250	300
2 horas	-	-	-	-	-
3 horas	06:50	07:20	-	-	-
4 horas	02:10	03:00	-	-	-
5 horas	02:10	03:00	03:50	07:10	-

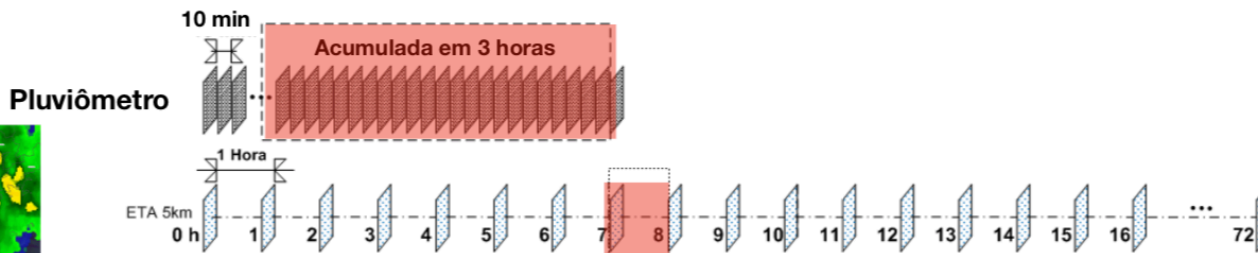
Introduction to TerraMA2

Plataforma para Monitoramento, Análise e Alerta Monitoring, Analysis and Alert Platform

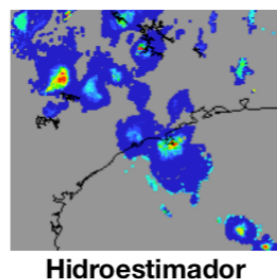
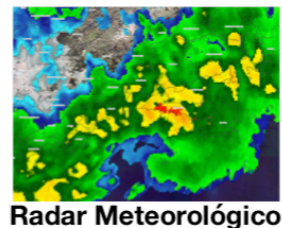
TerraMA2 software que provê a Infraestrutua Tecnológica necessária para implementar um Sistema de Monitoramento e Alerta de para riscos ambientais



Alert model - Case study



Observation
+
Forecast



```
local var1 = maximo_eta ('eta5km', 1)
local var2 = accum ('pluviometro', 3)
```

```
local var3 = var1 + var2
if var3 > 250 return 3
else if var3 > 200 return 2
else if var3 > 150 return 1
```




Acum. em	Alerta Acumulado acima de (mm)			
	150	200	250	300
2 horas	07:50	-	-	-
3 horas	03:10	07:20	-	-
4 horas	02:30	03:10	06:00*	-
5 horas	02:30	03:20	03:50	04:20



Acum. em	Alerta Acumulado acima de (mm)			
	150	200	250	300
2 horas	-	-	-	-
3 horas	06:50	07:20	-	-
4 horas	02:10	03:00	-	-
5 horas	02:10	03:00	03:50	07:10

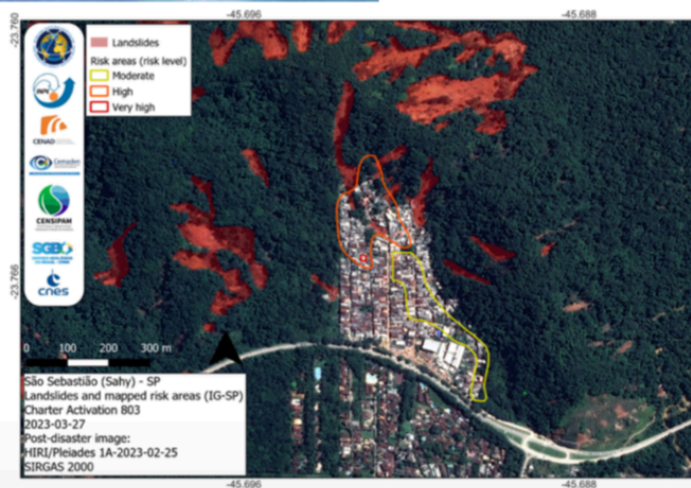
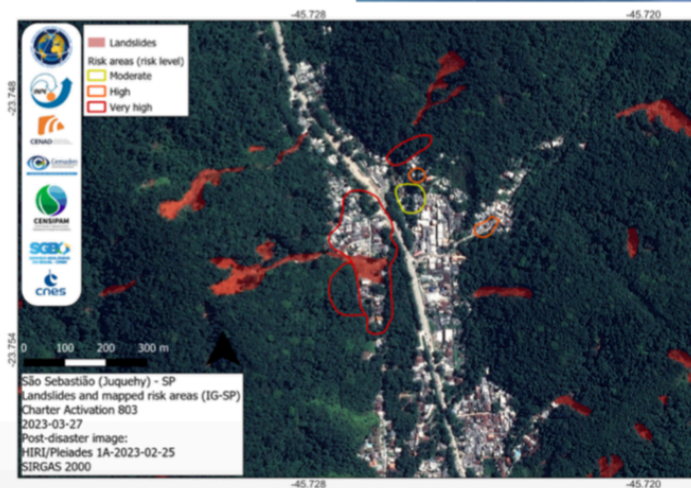
An aerial photograph of a coastal city, likely San Francisco, showing a red-outlined area on a hillside. The red outline follows a path or boundary through a green, hilly area. The city's urban landscape is visible below the hillside, and the ocean is at the bottom of the frame. A yellow and orange area is visible in the top left corner.

Alerta às

	02:30
	03:10
	03:50

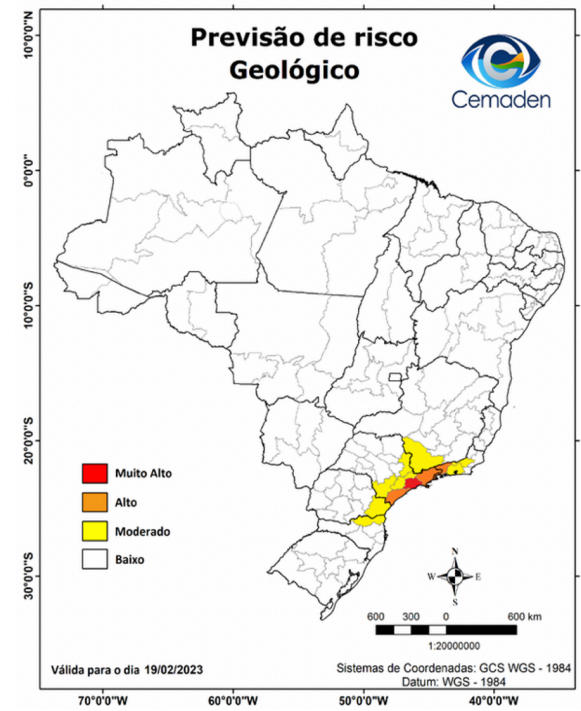
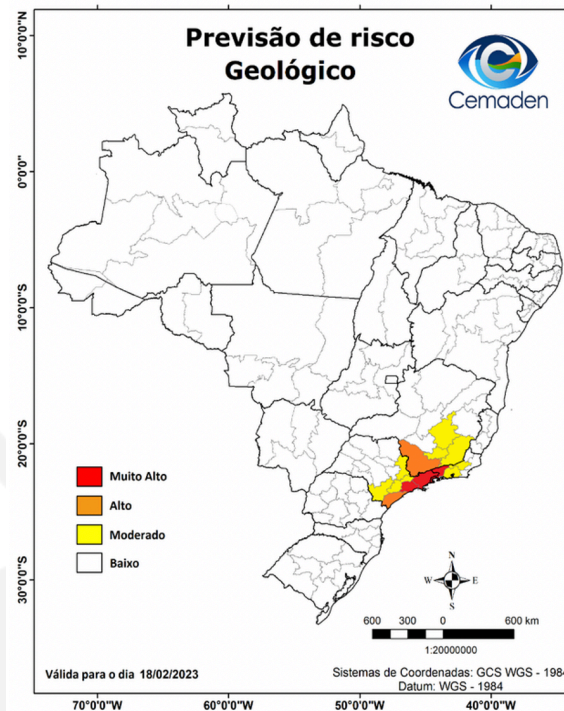
Alerta às

	02:10
	03:00
	03:50



São Paulo, Brazil – February/2023

Daily forecasts of geological risk (landslides and debris flow) issued by CEMADEN valid from February 18th and 19th 2023. Source: CEMADEN.



ADAPTABRAZIL MCTI

<https://adaptabrasil.mcti.gov.br/>



BRASIL

CORONAVÍRUS (COVID-19)

Simplifique!

Participe

Acesso à informação

Legislação

Canais



Início

Dados e Impactos

Notícias

Sobre

Contato


AdaptaBrasil MCTI

Índices e Indicadores de risco de impactos das mudanças climáticas no Brasil, integrados em uma única plataforma


[Acesse a plataforma](#)


“Aims to consolidate, integrate and disseminate information to support the advances on the analysis of observed and projected climate change in the Brazilian territory, informing decision makers for planning adaptation actions and strategies.”






Brasil





558 Microrregiões





< [Todos os Impactos](#)

< [Água](#)

< [Chuva](#)



Exposição

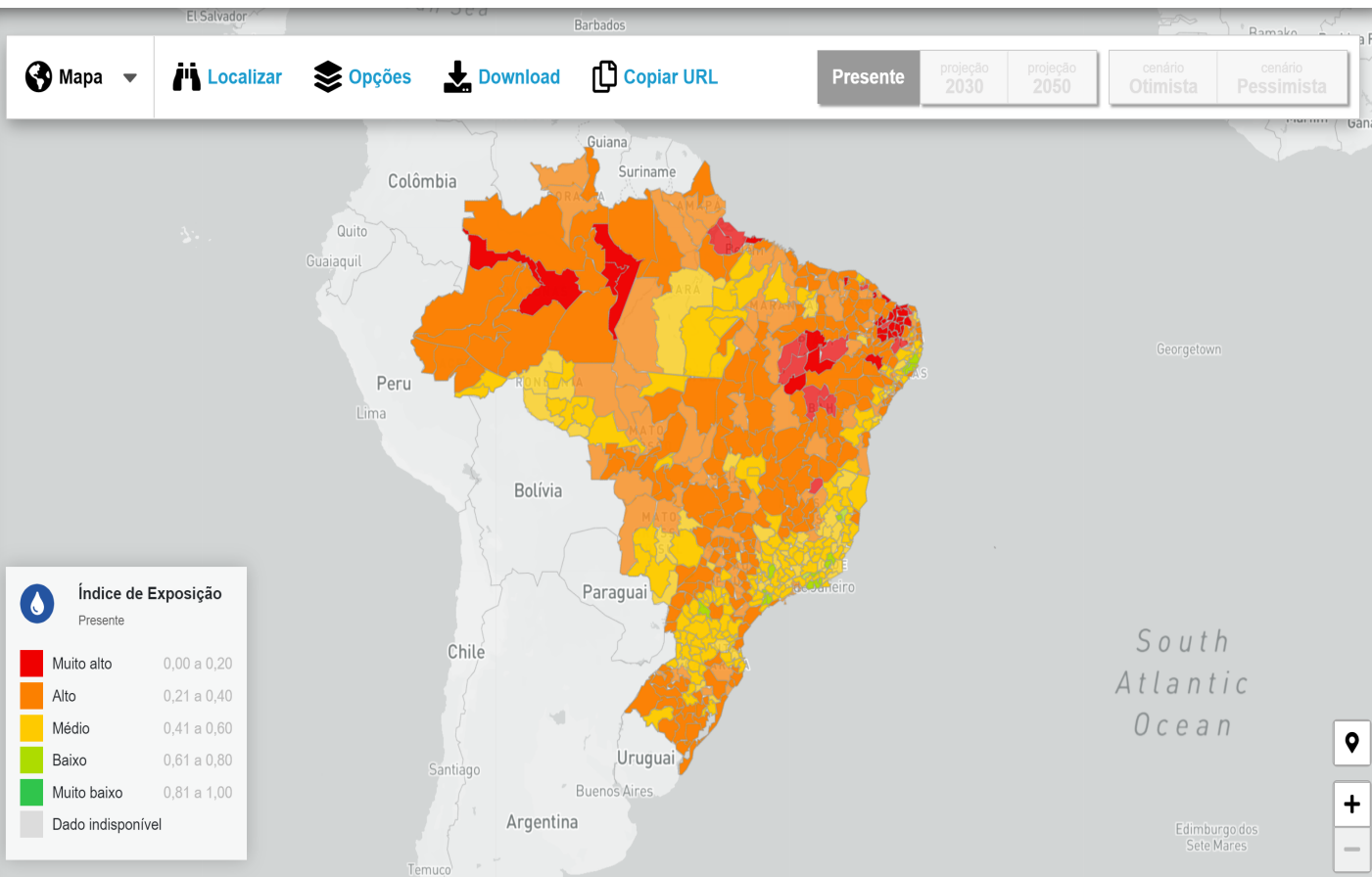
Índice de Exposição para Chuva

Magnitude do contato entre o sistema socioecológico e as perturbações climáticas relacionada a chuvas intensas por meio da distribuição de elementos de superfície

[Mais sobre esse dado](#)

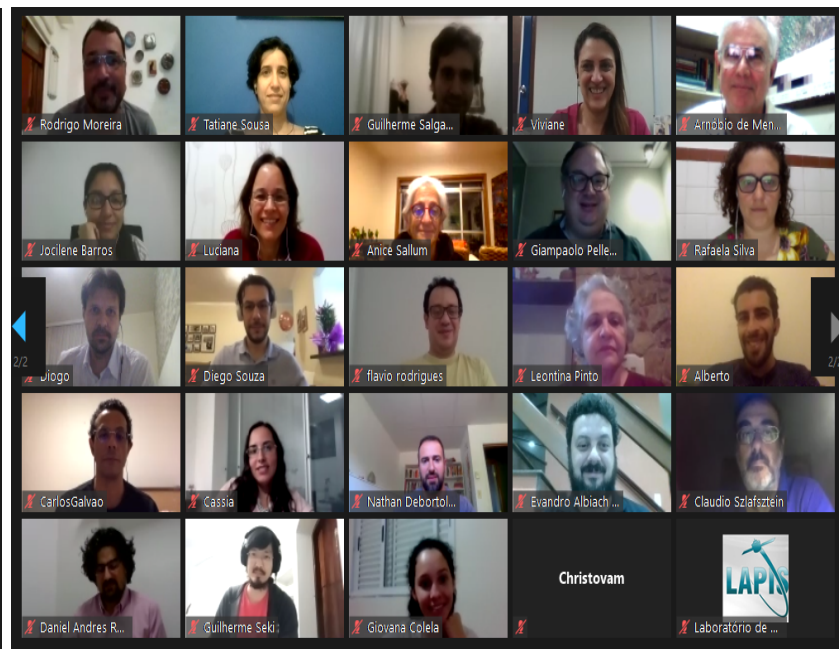
[Exposição Biofísica](#)

[Ocupação do Espaço](#)



Importance of Multi-Stakeholder Engagement

Oficina Indicadores: Brasil (julho/2019)



Oficina indicadores: Semiárido (junho/2019)



Design Sprint (abril/2018)

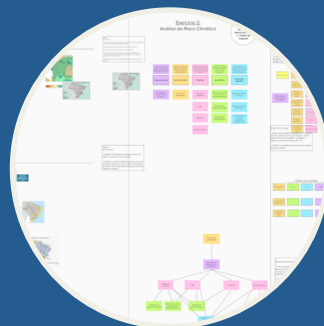
Workshop of Climate Risks and Adaptation



Main concepts
of climate risks
and adaptation



Based on
customized
study case and
guided
exercises



Web tools,
mental maps,
group
interaction



Cooperation for
Building
Capacity



MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA
E INOVAÇÃO



Final Remarks

Although alerts for high-risk hydrological and geological disasters were issued in a timely manner, they did not effectively reach or prompt action from all vulnerable populations. This underscores the need for a more comprehensive Early Warning System (EWS) that not only identifies hazards but also ensures that warnings are understood and acted upon by those at risk.

A multi-level governance approach that combines EWS with contingency plans can significantly reduce vulnerability and exposure, ultimately saving lives in the face of climate-related disasters





MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

OBRIGADO
THANK YOU FOR YOUR ATTENTION

Lincoln Muniz Alves

lincoln.alves@inpe.br



@lincolnalves

INPE/CGCT/DIIAV
São José dos Campos
São Paulo, Brasil
Telefone: +55 (12) 3208 7797
www.inpe.br