



Operational Ultraviolet Forecast System for South America: Analysis, Evaluation and Measurements

**Center for Weather Forecast and Climate Studies (CPTEC)
Brazilian National Institute for Space Research (INPE)**

Simone Sievert da Costa
Marcos Rodrigues, **Marcelo de Paula Correa*** and Juan C. Ceballos

***Research is under development in collaboration with University of Itajuba - MG**

satelite.cptec.inpe.br



TALK OUTLINE

- **Operational UV Forecast System at CPTEC-INPE**
 - Webpage (tool for communication / products)
 - method used for the UV index calculation
- **Evaluation of UV index**
 - Experimental campaign at Sao Paulo city
- **Temporal and Spatial variation of UV index over Brazil**
 - Important information for health sectors to develop campaign to reduce diseases related sun exposure
- **Who are the users/ how information has been used**



Satellite webpage of CPTEC-INPE

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Sistemas Ambientais

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- Tempo
 - Classificação de Nuvens
 - Descargas Elétricas
 - Nevoeiros
 - Monitoramento de Secas
 - Precipitação por Radar
 - Precipitação por Satélite
 - Sistemas Convectivos
 - Temperatura de Brilho
 - Vento na Troposfera
- Radiação na Atmosfera
 - Atraso Zenital
 - Índice Ultravioleta
 - Radiação Solar e Terrestre
- Superfície e Atmosfera
 - Aerossol
 - Índice de vegetação
 - Produtos MODIS
 - Queimadas
 - Sondagens
 - Temp. Superf. Continental
- Oceano
 - Prod. Meteo-Oceanográficos
 - Temp. Superf. Mar
- Coleta de Dados
 - Plataforma Coleta de Dados
 - Bóias

GOES MSG GOES + MSG NOAA AQUA TERRA



INPE/CPTEC/DSA NOAA CPTEC 200911081700

Satélite Goes
O GOES é um dispositivo de 5 canais espectrais sendo um Visível (0,55-0,75 µm), três canais Infravermelhos (3,8-4,0 µm, 10,2-11,2 µm, 11,5-12,5 µm) e o canal de Vapor d'Água (6,5-7,0 µm). No canal Visível, a resolução é 1 km. Nos canais Infravermelhos, a resolução é de 4 km. No canal Vapor d'água, a resolução é de 8 km.

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Selecione a Região para Visualizar



[Visualize América do Sul](#) [Animação](#)

- APLICATIVOS**
- Animações
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 - Treinamento a Distância
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- 2008-08.13 | VEJA PRODUTO



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- » Satélites Meteorológicos
 - » Informações do GOES
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<http://satelite.cptec.inpe.br>



Radiação Ultravioleta

Camada de Ozônio e Saúde humana



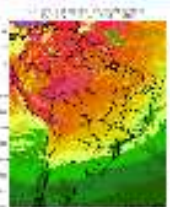
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Índice ultravioleta atual

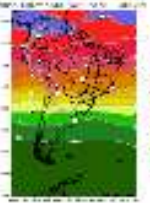
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Índice corrigido, considerando a nebulosidade observada por satélite. (Atualiz. a cada 30 min.)

- [Brasil](#)
- [Estado de São Paulo](#)
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- [Regiões: Sul, Sudeste, Centro-Oeste, Nordeste, Norte](#)
- [Imagens anteriores](#)
- [Mais informações sobre o efeito de nuvens](#)

Previsão do índice ultravioleta máximo

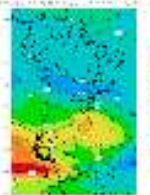


Previsão de valores máximos diários do IUV para condições de céu claro (sem nuvens).

Índice UV hoje

- [Brasil](#)
- [Regiões: Sul, Sudeste, Centro-Oeste, Nordeste, Norte](#)
- [Índice para os próximos 5 dias](#) - Animação
- [Previsão para sua cidade](#)

Previsão do conteúdo de ozônio



Conteúdo total de ozônio com base em medidas do satélite NOAA-16 (sensor SBUV/2).

- [Para hoje](#)
- [Animação para os próximos 5 dias](#)
- [Regiões: Sul, Sudeste, Centro-Oeste, Nordeste, Norte](#)

Informações úteis e importantes



O que você precisa saber sobre ozônio, radiação UV e saúde numa linguagem simples.

- [O que é radiação UV ?](#)
- [O que é o índice UV ?](#)
- [Radiação UV e saúde](#)
- [Ozônio](#)
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- [Radiação solar e terrestre](#)

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Caro Usuário, participe de nossa [Pesquisa R-UV](#)

Portuguese version



Radiação Ultravioleta

Camada de Ozônio e Saúde humana

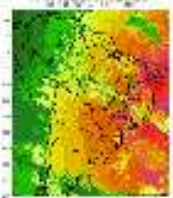


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Índice ultravioleta

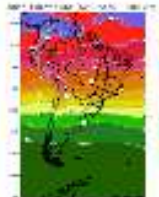


Índice corregido, considerando la nubosidad observada por satélite.
(Atualiz. a cada 30 min.)

[Mas informaciones](#)

Clique en las imagenes y en los links

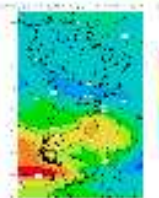
Previsión del índice ultravioleta



Previsión de valores máximos diarios del IUUV para condiciones de cielo claro (sin
nubes).

Clique en las imagenes y en los links

Previsión del contenido del ozono



Evaluación del contenido total de ozono en base a las medidas del sensor
TOMS(Earth Probe) y del SBUV/2 (NOAA).

Clique en las imagenes y en los links

Informaciones utiles e importantes



Todo lo que usted
necesita saber sobre la
exposición al sol, efectos
sobre la salud, radiación
UV y ozono en un
lenguaje simple.

- [O que es radiación UV](#)
- [O que es el índice UV](#)
- [Radiación UV y la salud](#)
- [La piel y los ojos](#)
- [Los protetores solares y el bronceado](#)

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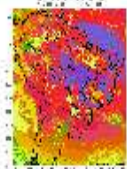
Señor/a
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[Investigación en
R-UV](#)

**Spanish Version
Collaboration with Universidad
Nacional de Asunción, Paraguay**



Índice ultravioleta atual

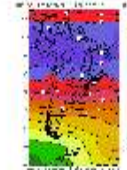
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Índice corrigido, considerando a nebulosidade observada por satélite. (Atualiz. a cada 30 min.)

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Previsão do índice ultravioleta máximo

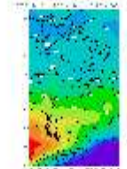


Previsão de valores máximos diários do IUV para condições de céu claro (sem nuvens).

Índice UV hoje

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- [Previsão para sua cidade](#)

Previsão do conteúdo de ozônio



Conteúdo total de ozônio com base em medidas do satélite NOAA-16 (sensor SBUV/2).

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- [Animação para os próximos 5 dias](#)
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Informações úteis e importantes



O que você precisa saber sobre ozônio, radiação UV e saúde numa linguagem simples.

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Caro Usuário,

What kind of information is provided on the website?

<http://satelite.cptec.inpe.br/uv/>



Radiação Ultravioleta
Camada de Ozônio e Saúde humana

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Índice ultravioleta atual Clique nas imagens e nos links

Índice considerado para condições de nebulosidade por satélite (Atualizado)

Previsão do índice ultravioleta
Previsão de máximos para condições de céu claro (sensor S)

Previsão do conteúdo de ozônio
Conteúdo com base do satélite (sensor S)

Informações úteis e importantes
Clique aqui para saber mais sobre ozônio UV e saúde humana em português

Conteúdo de Ozônio (D.U.) para 06JAN2010

DSa/CPTec/INPE

P & D
- DSA/CPTec
- Glossário de radiação

Ozone Concentration NCEP + Forecast
(Long et al., 1996-BAMS)
Geopotential – 500 & 100 hPa
Temperature at 50 hPa



Radiação Ultravioleta
Camada de Ozônio e Saúde humana
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Índice ultravioleta atual

Índice considerado nebuloso por saturação. Atual

Previsão do índice ultravioleta

Previsão máxima para o dia claro

Previsão do conteúdo de ozônio

Conteúdo com base do satélite (sensibilidade)

Informações úteis e interessantes

O que você precisa saber sobre UV e saúde

UV

Índice Ultravioleta (IUUV) para 05JAN2010

DSa/CPTEC/INPE

Forecast of max UV index without clouds at solar noon (recommended by WHO)

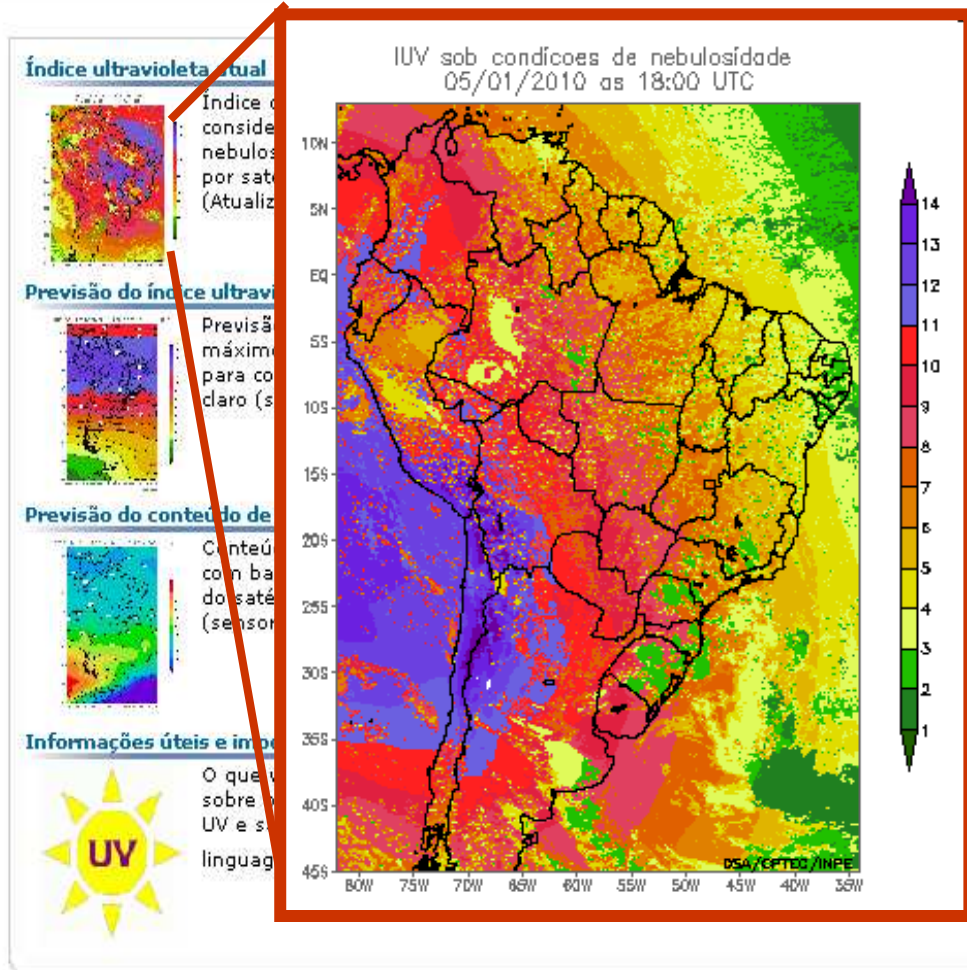
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Pesquisa R-UV



<http://satelite.cptec.inpe.br/uv/>



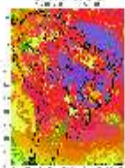
UV index every 30 min.
 clear and cloudy.
 (called UVI Instantaneous)

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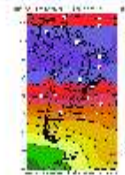
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Índice corrigido, considerando a nebulosidade observada por satélite. (Atualiz. a cada 30 min.)

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Previsão do índice ultravioleta máximo

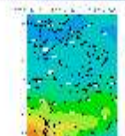


Previsão de valores máximos diários do IUV para condições de céu claro (sem nuvens).

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Conteúdo total de ozônio com base em medidas do satélite NOAA-16 (sensor SBUV/2).


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How UV index is estimated?

Radiative Transfer is developed by Correa et al. (2004) based on Eddington approx.

$$\mu \frac{dI_{\lambda}(\mu, \phi, \tau)}{d\tau} = I_{\lambda}(\mu, \phi, \tau) + \frac{\omega_0 \lambda}{4\pi} \int_0^1 \int_{-1}^1 I_{\lambda}(\mu, \phi, \tau) P(\cos \Psi) d\mu d\phi$$

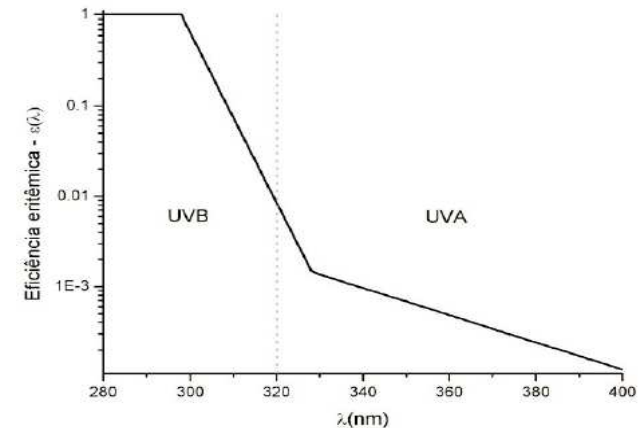
Input data into RT-Model

- Ozone Concentration (from NOAA);
- Cloud (cloud classification from GOES);
- Surface pressure (from ETA 20 km) ,
- Background aerosol ($\delta=0,2$ and $\omega=0,9$)
- Surface reflectance = 0,3 (urban areas, EPA, WMO-1999)

The monochromatic irradiance from 280 to 400 nm

$$S = \int_{280\text{nm}}^{400\text{nm}} \epsilon_{\lambda} I_{\lambda} d\lambda \quad [\text{W/m}^2]$$

Erythemal action spectrum (from MacKinlay and Diffey, 1986)



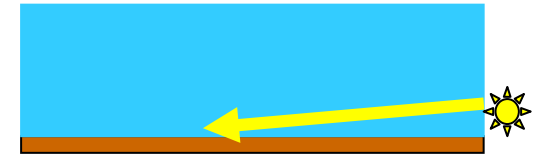
$$1 \text{ IUUV} \equiv S_{\lambda} = 25 \text{ mW/m}^2$$



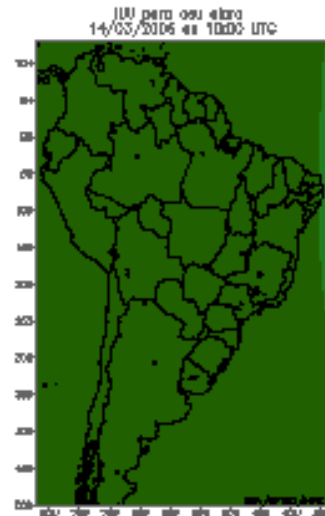
Clear sky UV index

Daily and Seasonal Variation

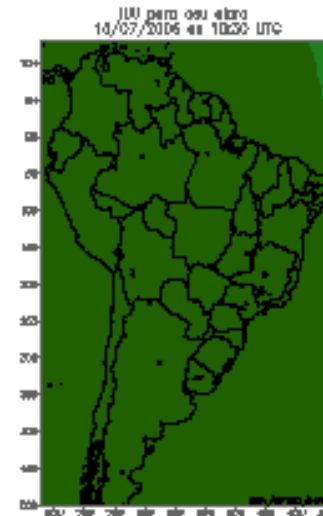
UV index instantaneous – 10:30 UTC



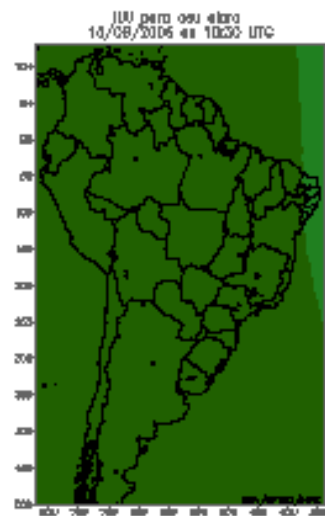
March



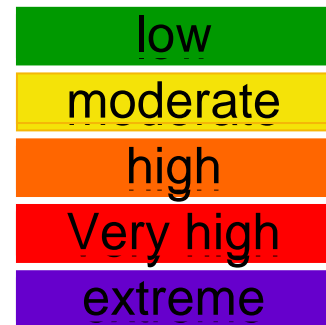
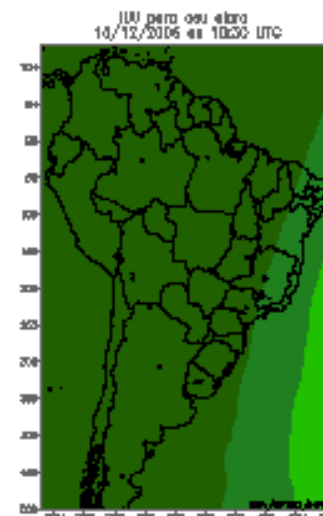
June



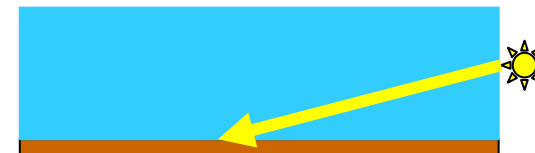
September



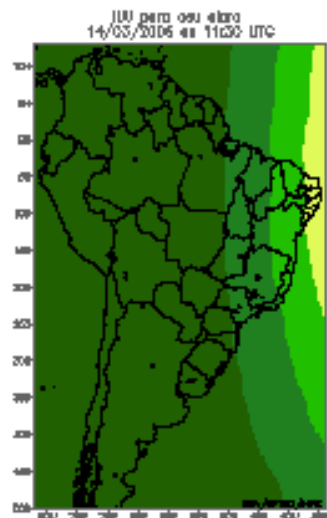
December



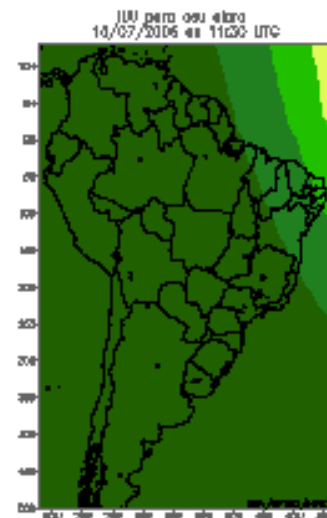
UV index instantaneous – 11:30 UTC



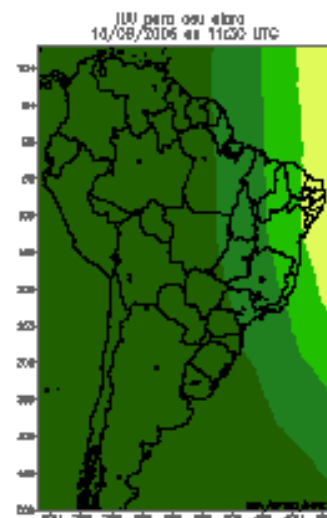
March



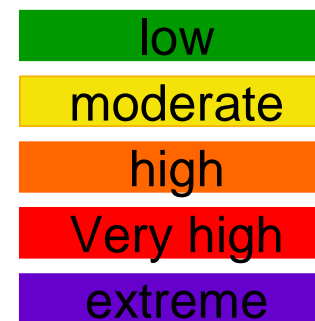
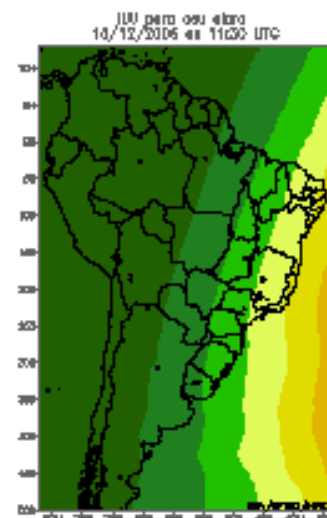
June



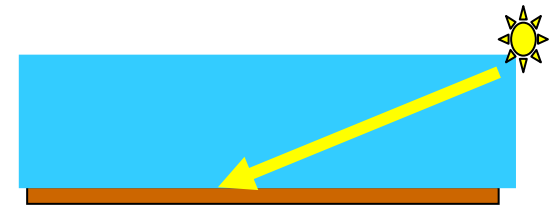
September



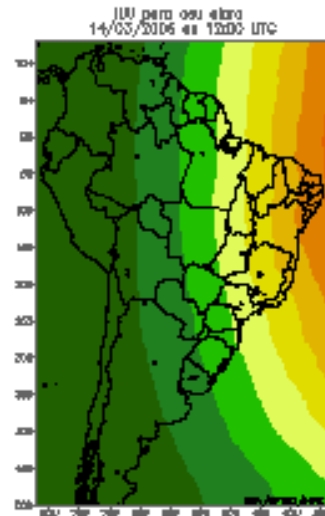
December



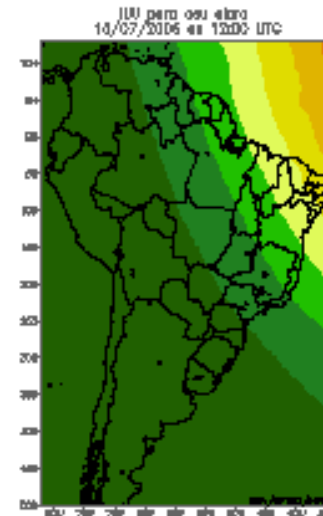
UV index instantaneous – 12:00 UTC



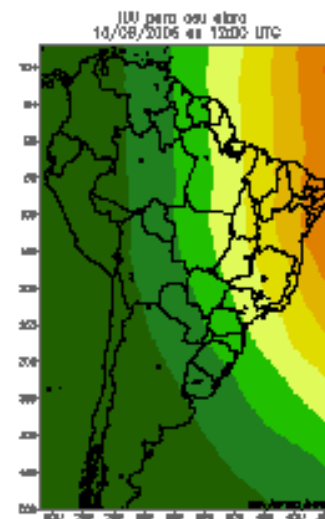
March



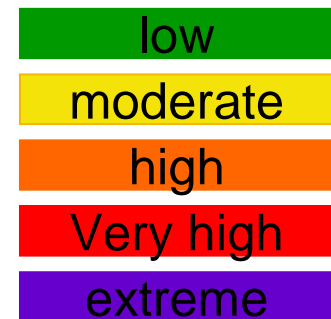
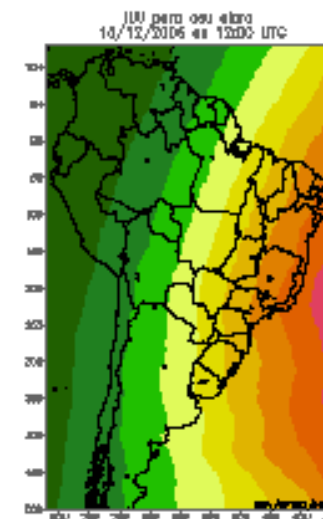
June



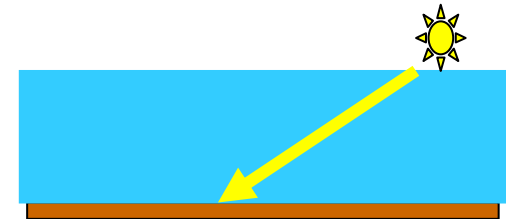
September



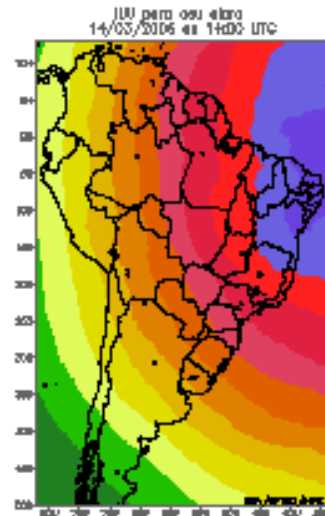
December



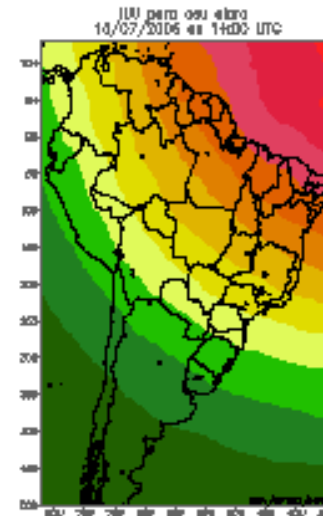
UV index instantaneous – 14:00 UTC



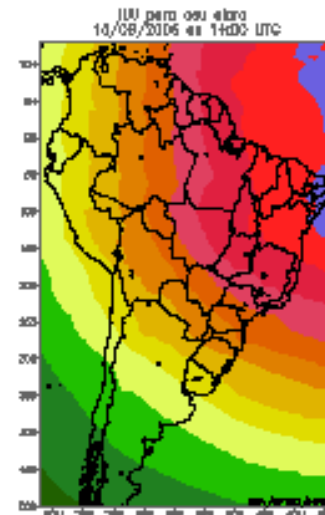
March



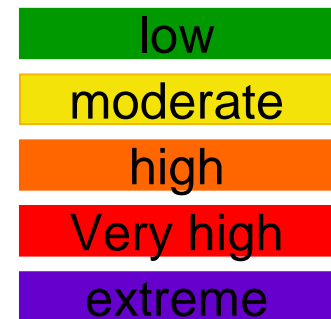
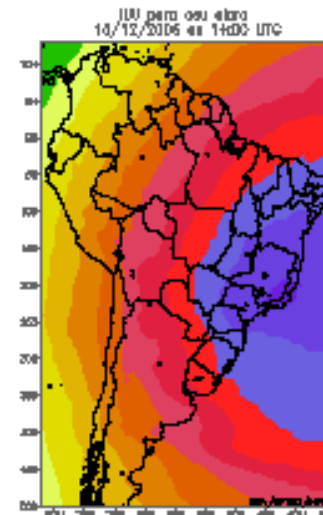
June



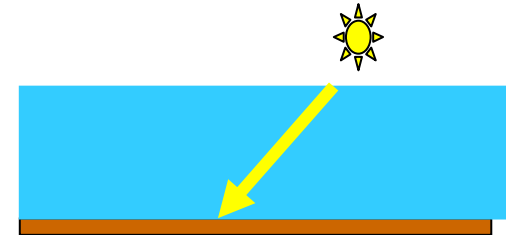
September



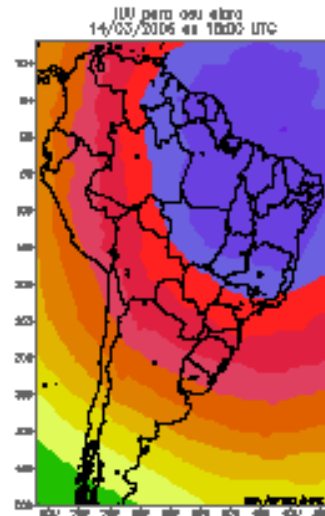
December



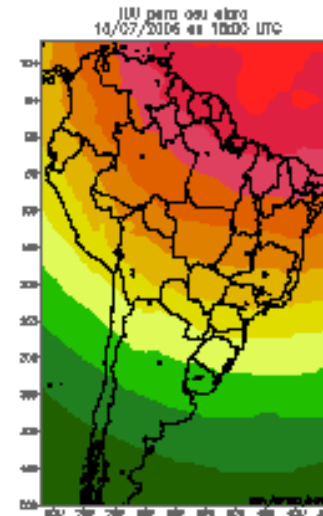
UV index instantaneous – 15:00 UTC



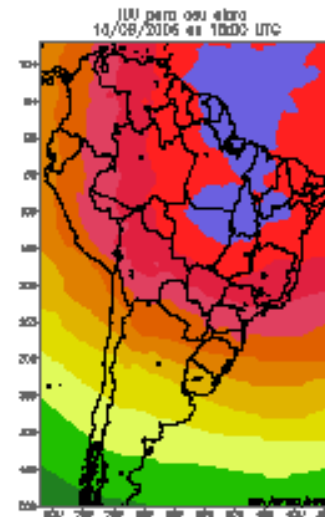
March



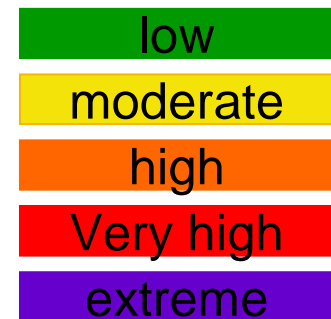
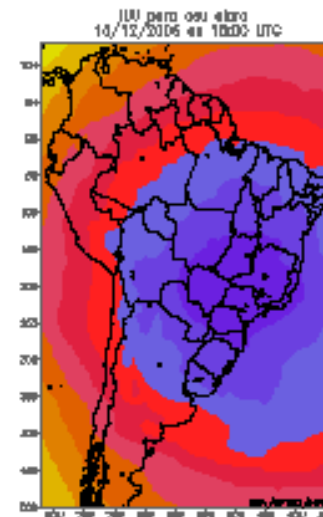
June



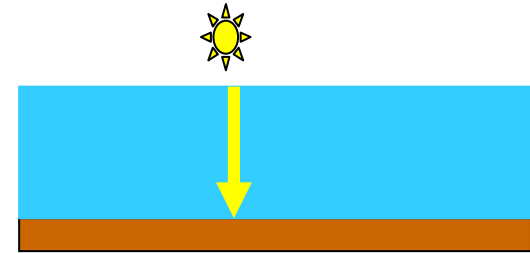
September



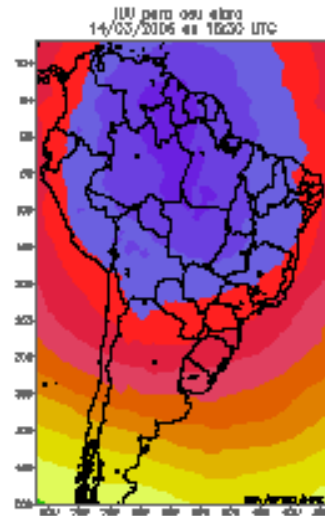
December



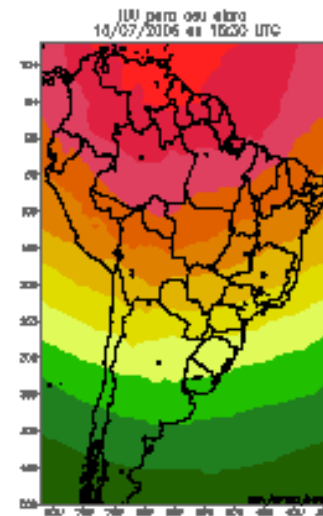
UV index instantaneous – 16:00 UTC



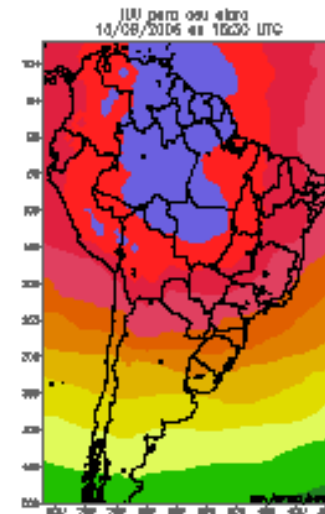
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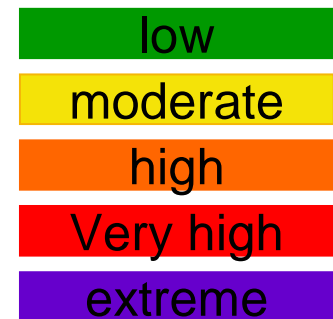
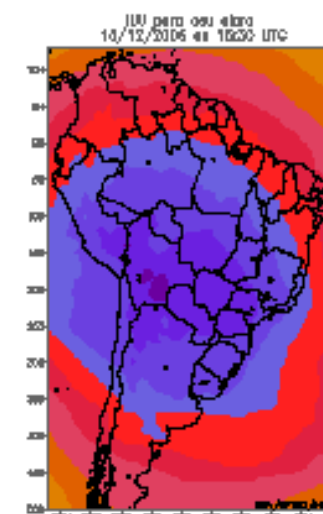
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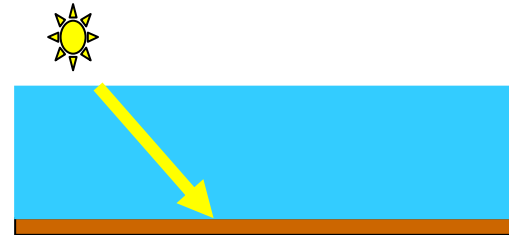
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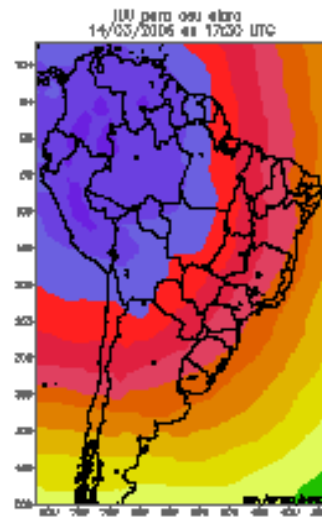
December



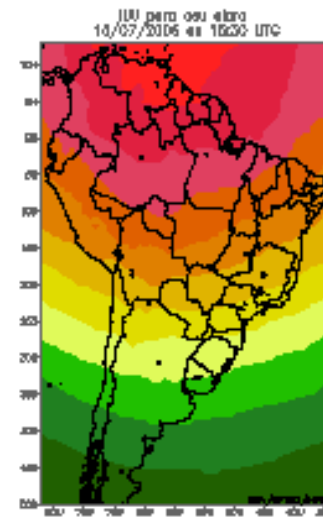
UV index instantaneous – 17:30 UTC



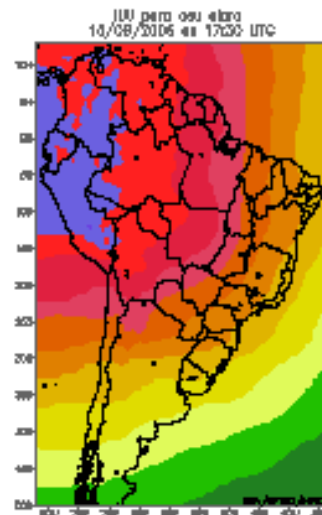
March



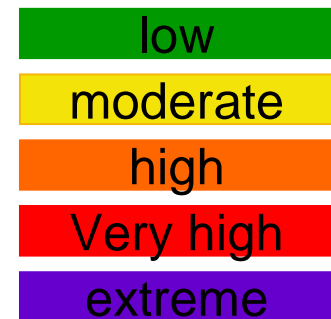
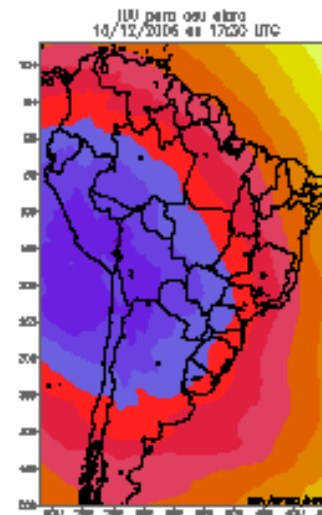
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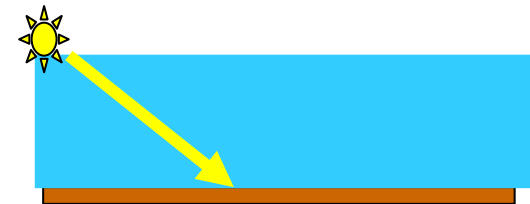
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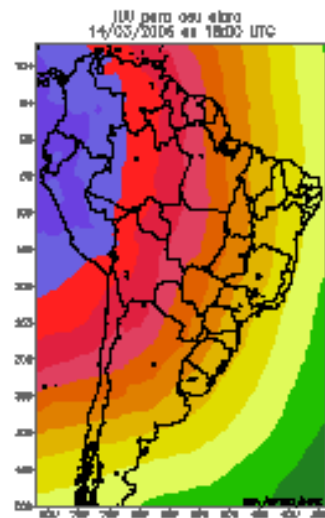
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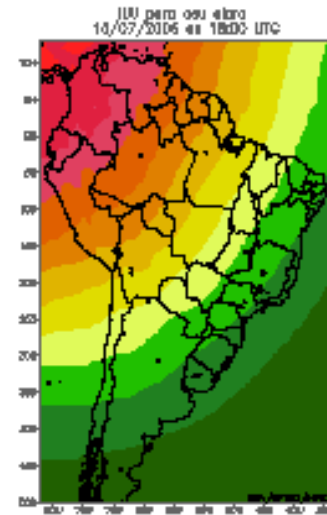
UV index instantaneous – 18:00 UTC



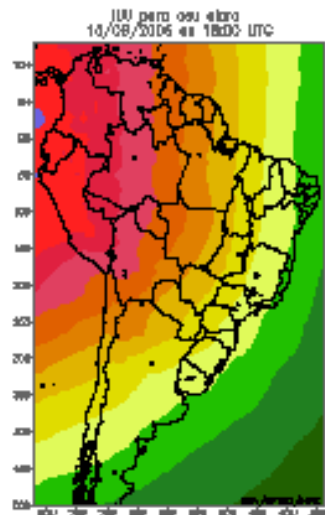
March



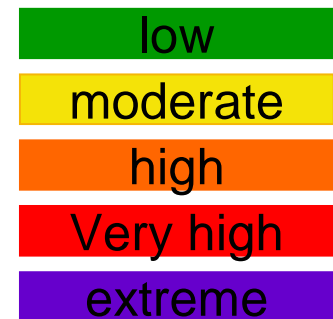
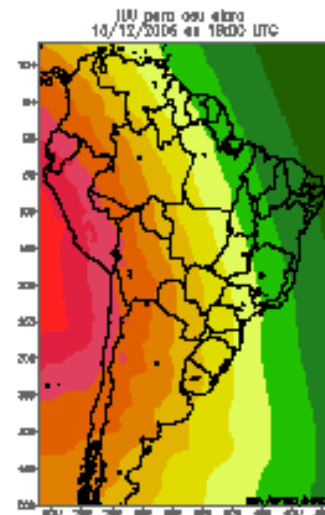
June



September



December





Cloud Effect on IUV

- According to Vanicek et al. (2000)

$$UVI_{\text{cld}} = CMF * UVI_{\text{clr}},$$

where CMF is Cloud Modification Factor that depends on cloud type and cloud cover

	 0%–25%	 25%–50%	 50%–75%	 75%–100%
High	1.0	1.0	1.0	0.9
Medium	1.0	1.0	0.8	0.5
Low	1.0	0.8	0.5	0.2
Fog	0.4			
Rain	0.2			

Vanicek et al. (2000)

Cloud Effect on IUUV

- GOES Cloud Classification:



Clouds classification based on GOES Ch 1&4 (Ceballos and Bottino, 2002)

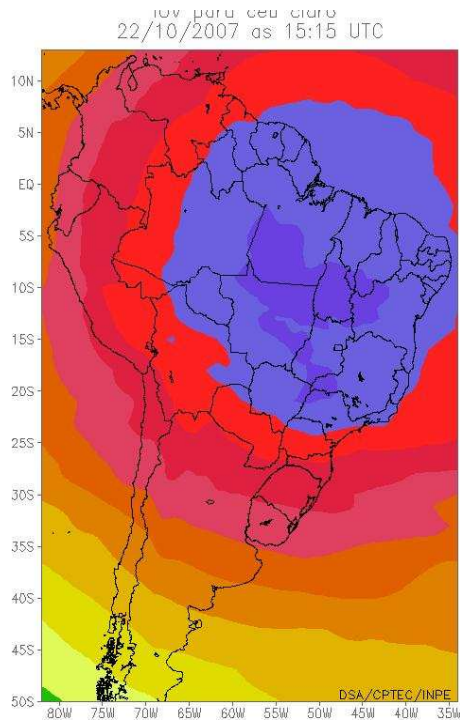
Cloud Modification Factor

Surface	CMF = 1.00
Cirrus	CMF = 0.90
Cumulus	CMF = 0.70
Stratus	CMF = 0.50
Deep convection / multi- layers	CMF = 0.30

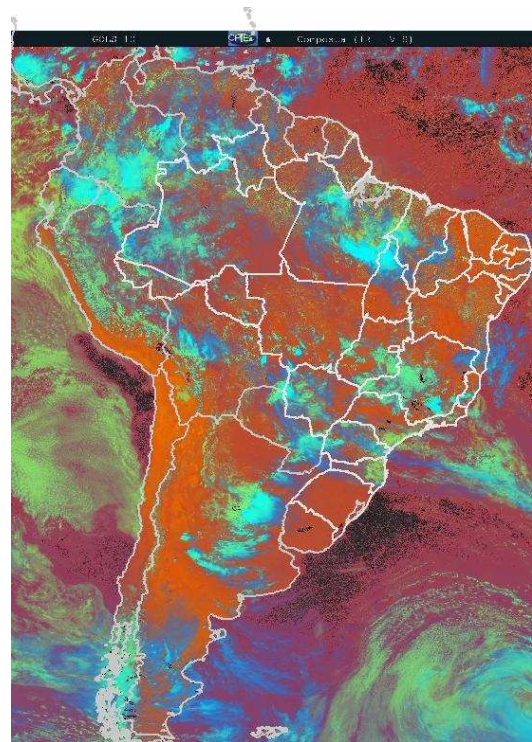


Cloud Effect on UVI

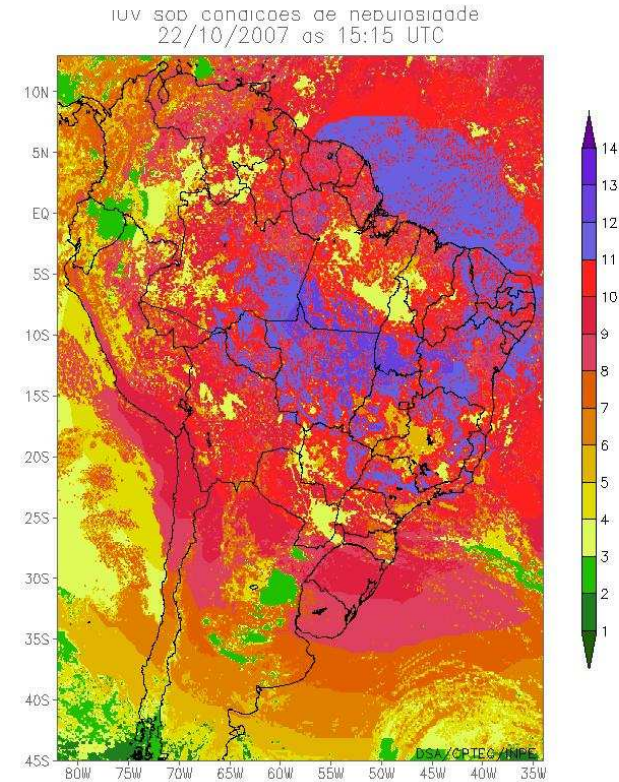
Clear sky UVI



GOES12 cloud class.



Cloudy UVI



Cúmulos



Estratos



Cirros



Multicamadas



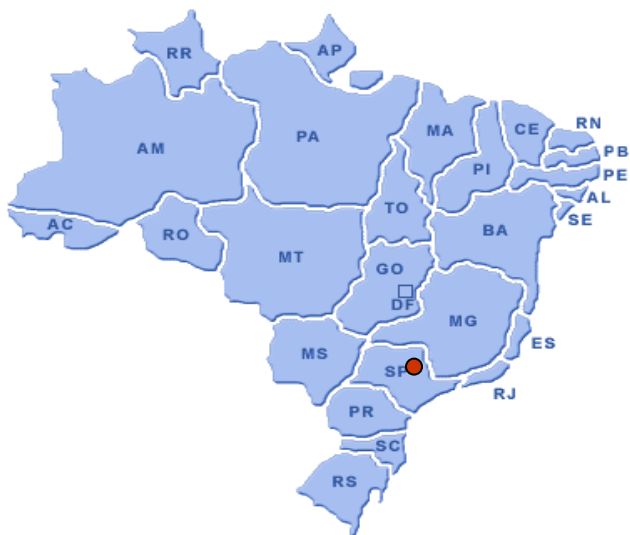
What is the performance of UV index estimative?

Observation from the project entitled **Study on the effect of atmospheric and geographical factors on ultraviolet radiation in São Paulo**

Funded by FAPESP n°04/00937-3

Coordinated by Dr. Marcelo Corrêa and Dr. Juan Ceballos

Study area

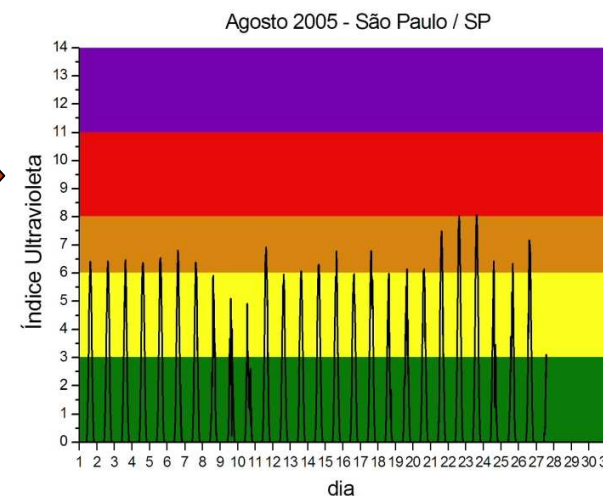


biologically effective
ultraviolet radiation
measurement



**Biometer UV501A
Solar Light
(280 – 320 nm)**

UV index





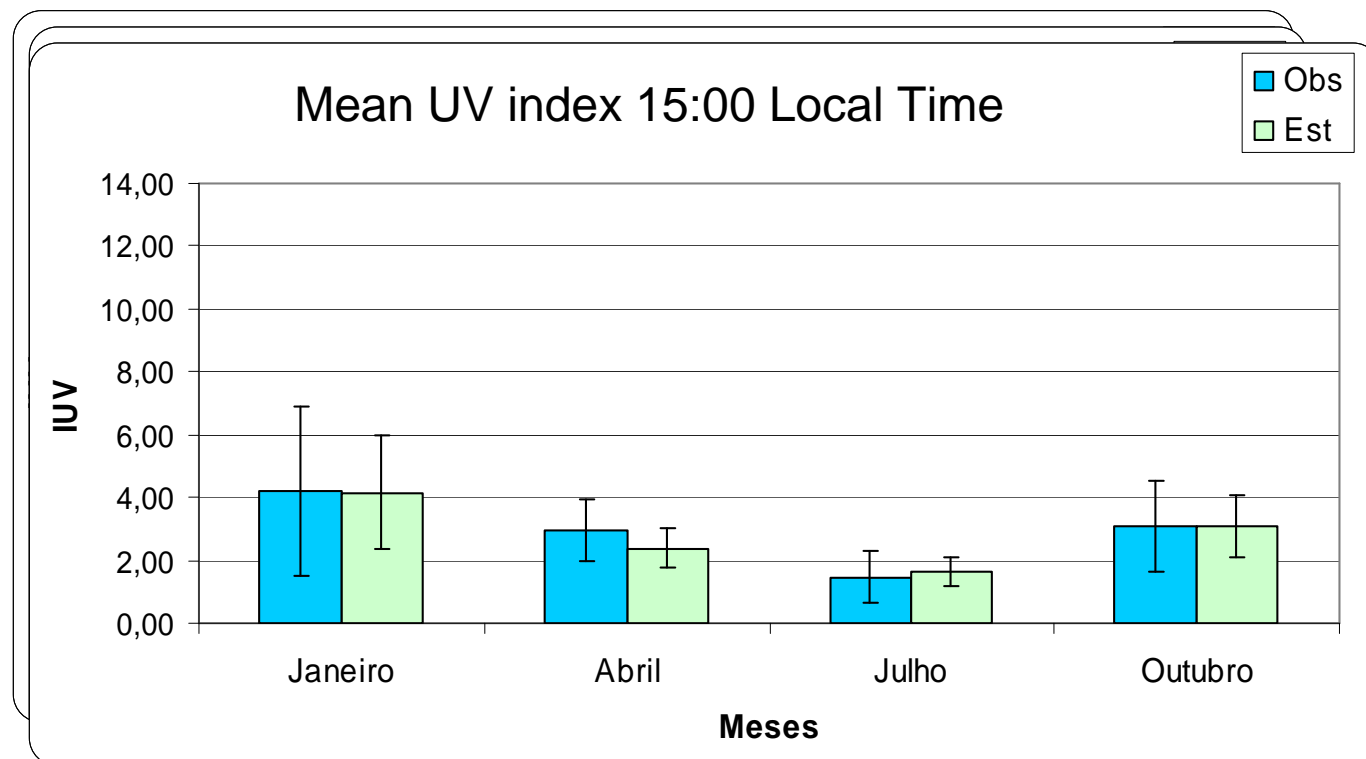
Comparison estimative v. observation UV index

Observational data:

Source: Measurements at São Paulo city, Period: June/2005 - March/2007 - Projeto UVSP (Corrêa *et al.*)

Estimates:

Source: CPTEC-INPE



Project PIBIC: Ultraviolet Index Evaluation and Monitoring over São Paulo, Domingues de Paula e Costa (2009)

Comparison estimative v. observation

		Estimative				Observation		Est. – Obs.
		cloudy sky		clear sky				
Time		mean	std.	mean	std.	mean	std	
Jan	9	4,09	1,26	4,99	0,22	4,11	1,60	-0,02
	12	8,99	3,01	12,80	0,27	8,77	3,75	0,22
	15	4,17	1,81	6,99	0,20	4,20	2,69	-0,03
Abr	9	2,15	0,64	2,58	0,29	2,39	0,72	-0,24
	12	5,86	1,69	7,80	0,81	6,91	2,56	-1,05
	15	2,39	0,62	3,16	0,49	2,96	0,98	-0,57
Jul	9	1,08	0,33	1,25	0,10	1,08	0,34	0,00
	12	4,19	1,22	4,87	0,35	3,71	2,20	0,48
	15	1,63	0,47	1,87	0,18	1,48	0,81	0,15
Out	9	3,66	1,50	5,11	0,50	3,67	1,99	-0,01
	12	8,10	2,54	11,18	0,71	7,71	3,07	0,39
	15	3,10	0,99	4,49	0,29	3,09	1,43	0,01

Project PIBIC: Ultraviolet Index Evaluation and Monitoring over São Paulo, *Domingues de Paula e Costa (2009)*



Who are the users?

Previsão de Tempo

Cidade	Mínima	Máxima	Condição	UV
São Paulo	18°C	22°C		UV 13
Teresina	24°C	37°C		UV 12
Vitória	23°C	35°C		UV 12

UV index is available together with other variables of weather forecast



Education Program on UV risk (Ribeirao Preto, SP).

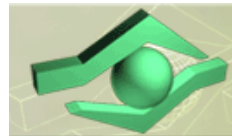


São Paulo State Program on Protection of ozone layer of



EPAGI/CIRAM - Empresa de Pesquisa Agropecuária e extensão rural de Santa Catarina/Centro de informações de recursos ambientais e de Hidrometeorologia de SC.

Previsao do tempo TV Vanguarda 2009



FUNDACENTRO –Foundation Specialized Service of Safety and *Work Medicine* In Santa Catarina



Bahia Meteorological Center, environmental office



Mato Grosso State health office



Thank you


Simone Sievert da Costa

simone.sievert@cptec.inpe.br



DSA



- 
- Long, C.S. et al., "Ultraviolet Index Forecasts Issued by the National Weather Service," *Bull. Am. Meteorological Soc.* **77**, 729-748 (1996)

Role of Meteorology

World Health Organization



World Meteorological Organization



United Nations Environment Programme



UNEP

International Commission on Non-ionizing Radiation Protection



THE ROLE OF NATIONAL GOVERNMENTS

EDUCATION

- Encourage the use of the UVI as part of public awareness programmes.
- Supply health care professionals, teachers and carers of children with educational material for distribution to the public.
- Organize workshops for medical doctors and other health professionals.
- Establish education programmes for teachers.
- Establish education programmes for outdoor workers.
- Encourage and support the provision of shaded areas in schools, playgrounds and parks, and in public places such as bus stops and swimming pools.
- Recommend against the use of sunlamps and sunbeds for cosmetic purposes.
- Inform the community of drugs and cosmetics that sensitize the skin to the effects of UV radiation.
- Enlist weather broadcasters, health reporters and the media to provide the UVI service to the public.

EVALUATION

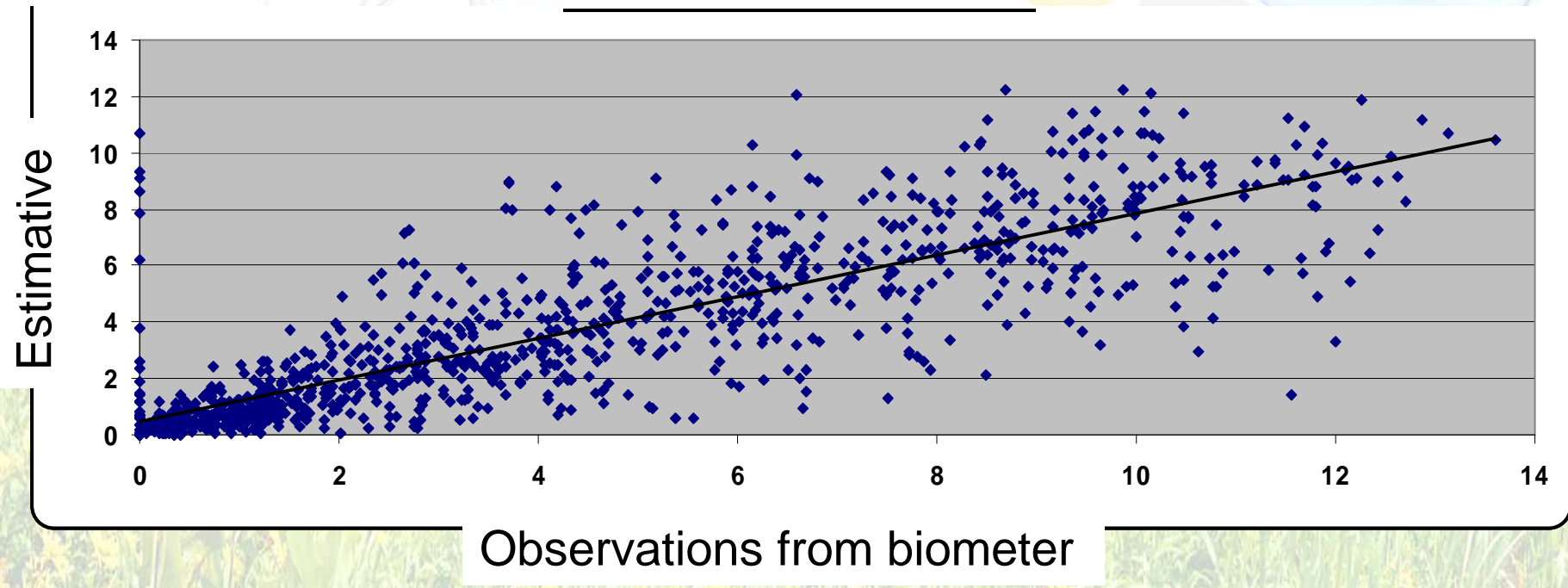
- Establish national statistics on UV radiation-induced skin and eye diseases.
- Encourage research on UV radiation related health effects and protective measures.
- Support national programmes and international collaboration efforts on UV radiation monitoring and health education.
- Conduct research that monitors behavioural, knowledge and attitudinal trends related to sun protection.

STANDARDS

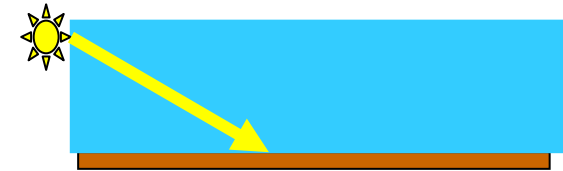
- Facilitate the development of standards related to sun protection products such as sunscreens, clothing, sunbeds and sunglasses to ensure clear and safe guidelines for manufacturers and consumers.
- Encourage the provision of information on the degree of UV radiation protection provided by sunscreens, eyewear, clothing and other protective measures.

Comparison estimative v. observation UV index

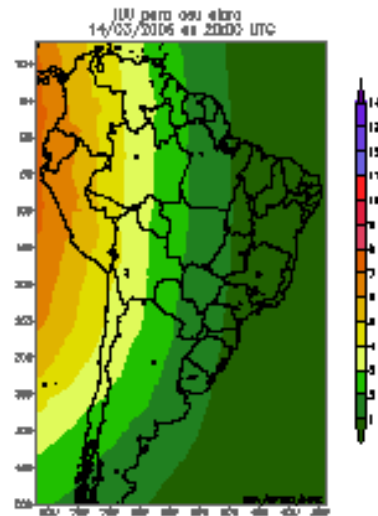
2005



UV index instantaneous – 20:00 UTC

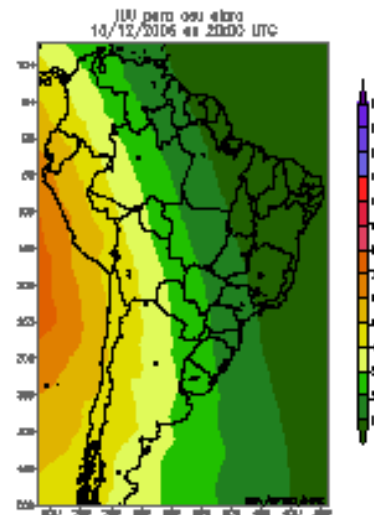
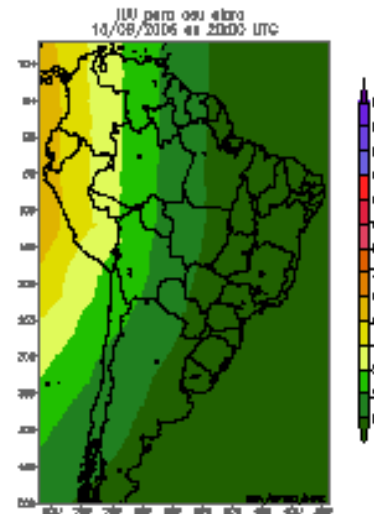


March

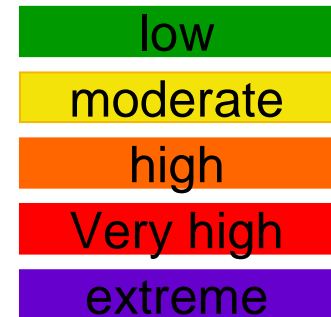


June

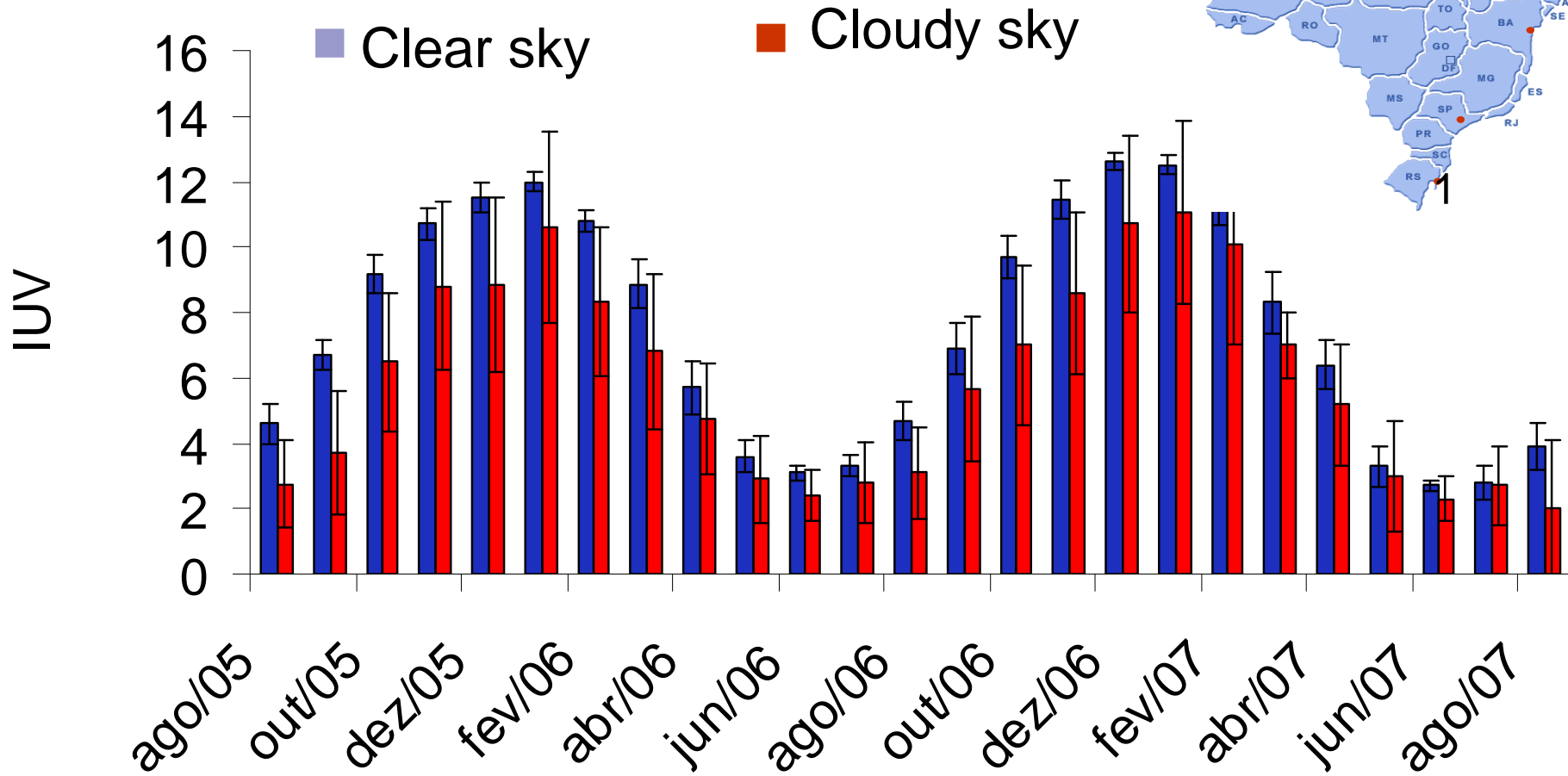
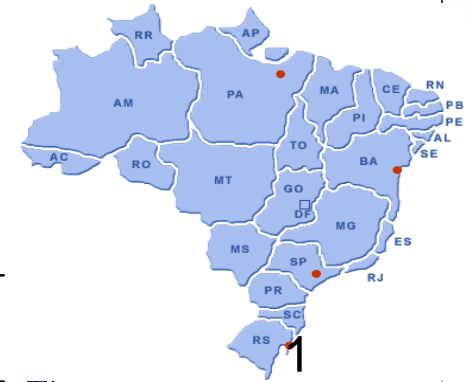
September



December

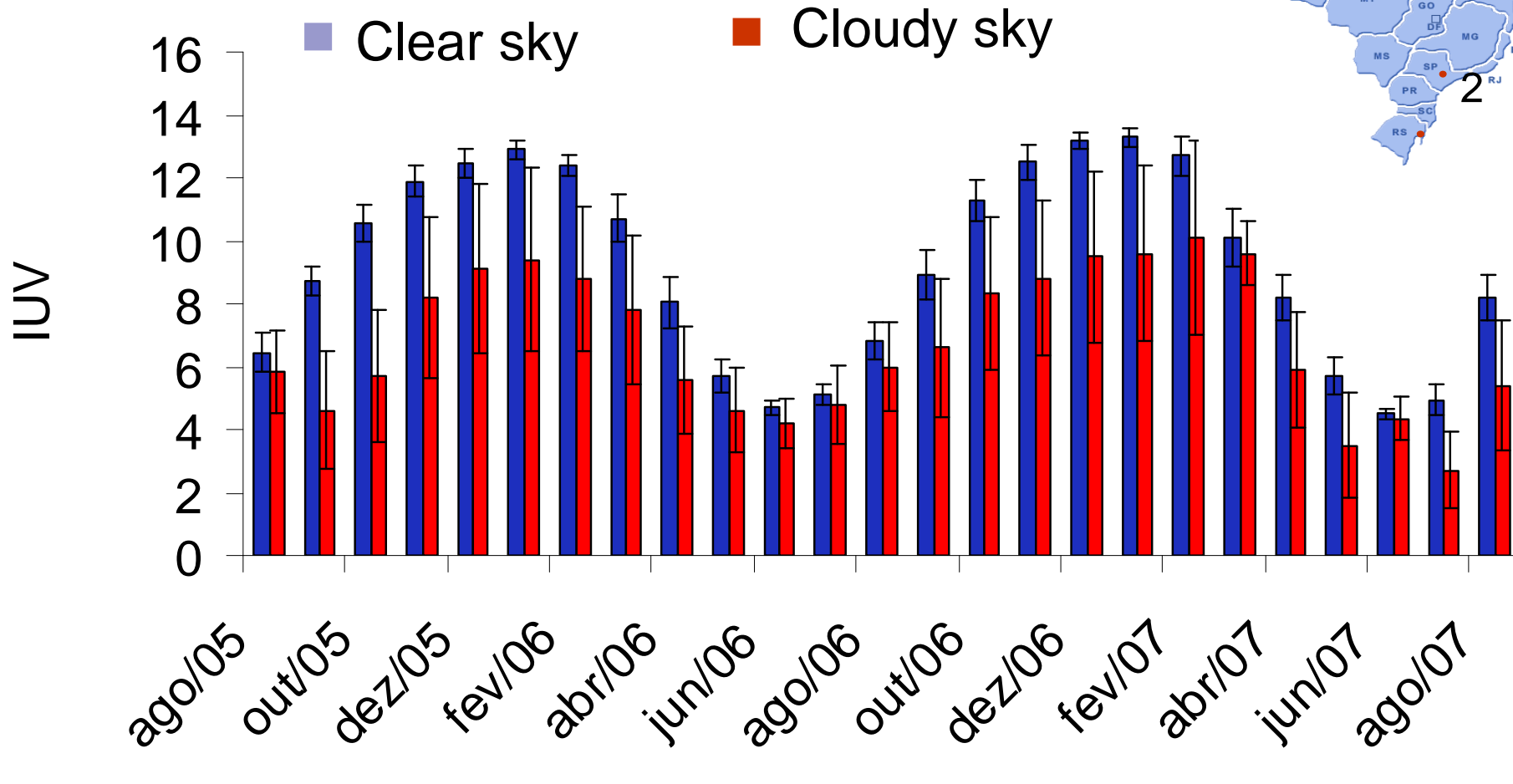
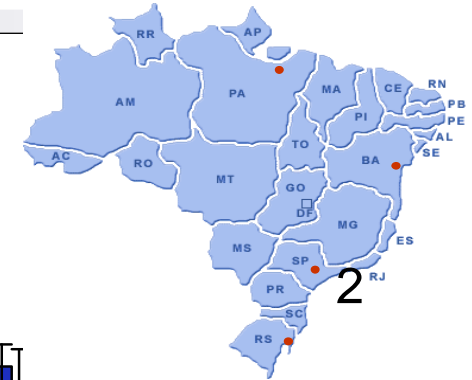


IUV - PORTO ALEGRE



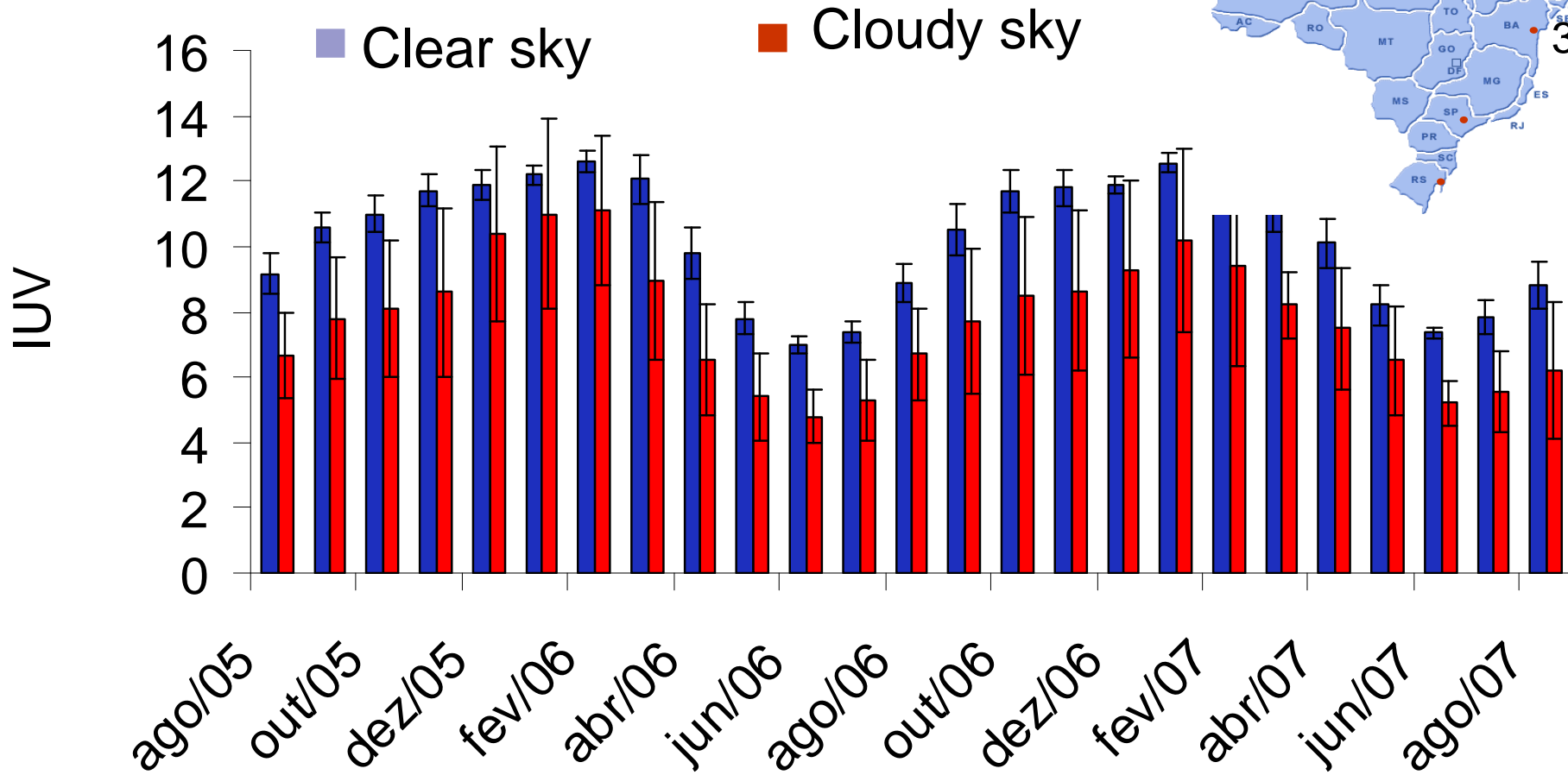
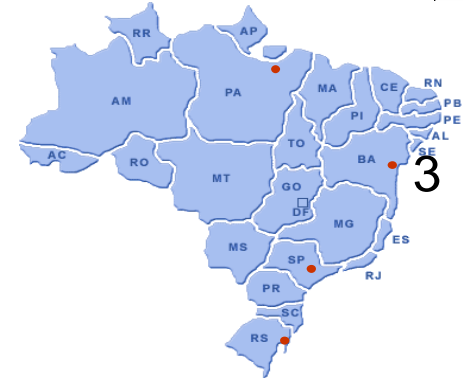
Nenhuma Precaução Necessária	Precauções Requeridas	Extra Proteção!!!
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IUV - SÃO PAULO



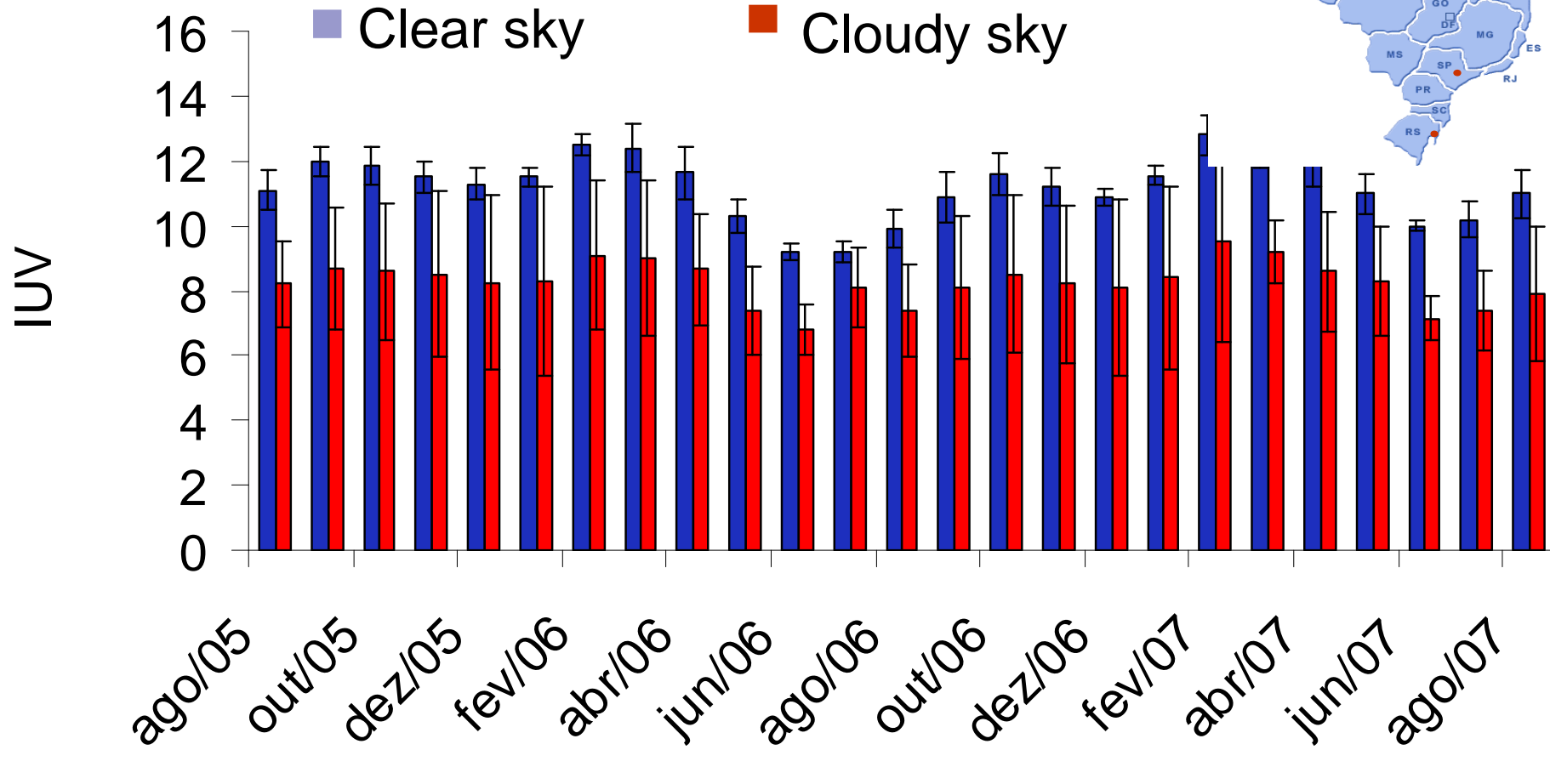
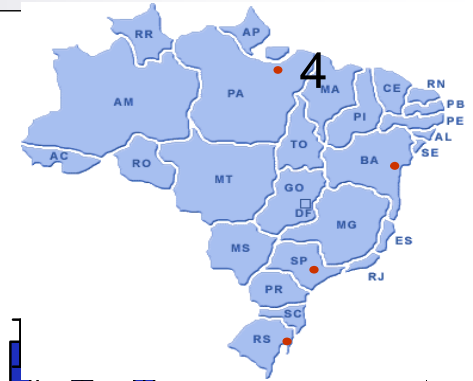
Nenhuma Precaução Necessária	Precauções Requeridas	Extra Proteção!!!
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IUV - SALVADOR



Nenhuma Precaução Necessária	Precauções Requeridas	Extra Proteção!!!
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IUV - BÉLEM



Nenhuma Precaução Necessária
Precauções Requeridas
Extra Proteção!!!