

Greening of the Amazon

Rise of renewable energy in Brazil

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Outline of this talk

- * Why?
- * Where?
- * How?
 - * WOD overview
- * Examples of applications

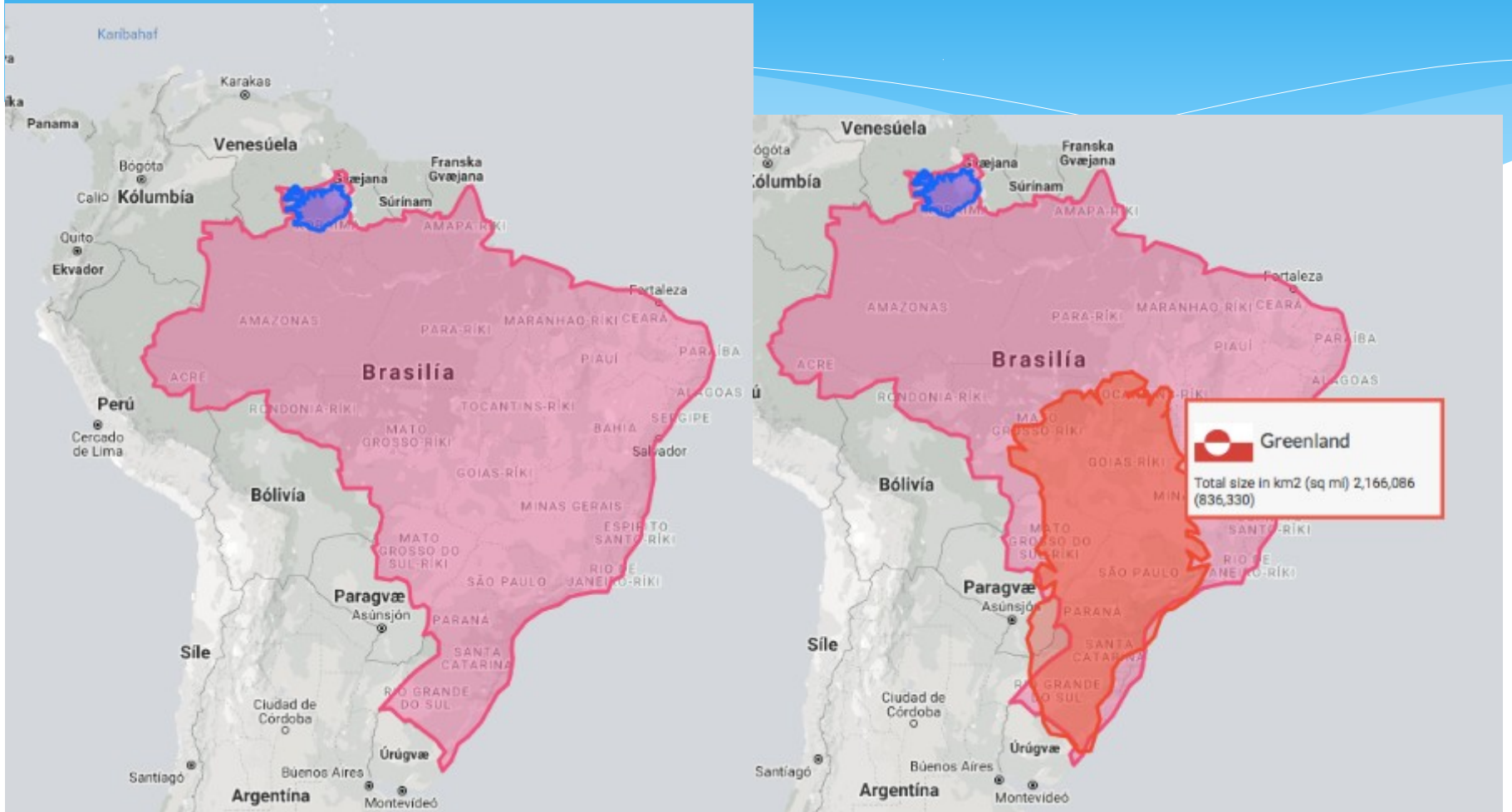
Why?

- * Brazil is the 5th largest country in the world by area and population
 - * 8.5 million km²
 - * 211 million in 2017
- * Ranked as the 8th largest economic area at the end of 2017
 - * 2.055 billion US\$ – 2.55% of the global GDP
- * Total installed capacity is 168,3 GW (owned by 47 companies)
 - * Hydro-power – 64% (1.319 power plants)
 - * Wind-power – 7,9% (511 wind parks)
 - * Solar-power – 0,6% (expected to increase by orders of magnitude in coming years)
- * 227 registered trading companies

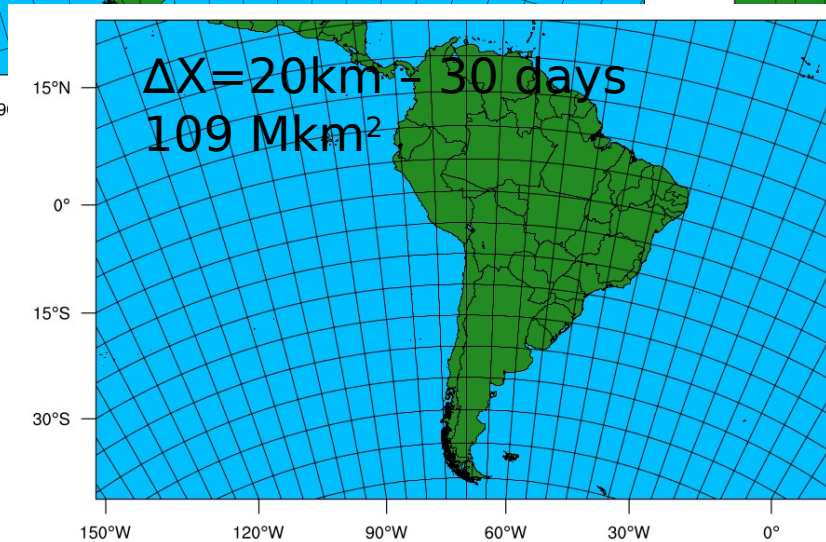
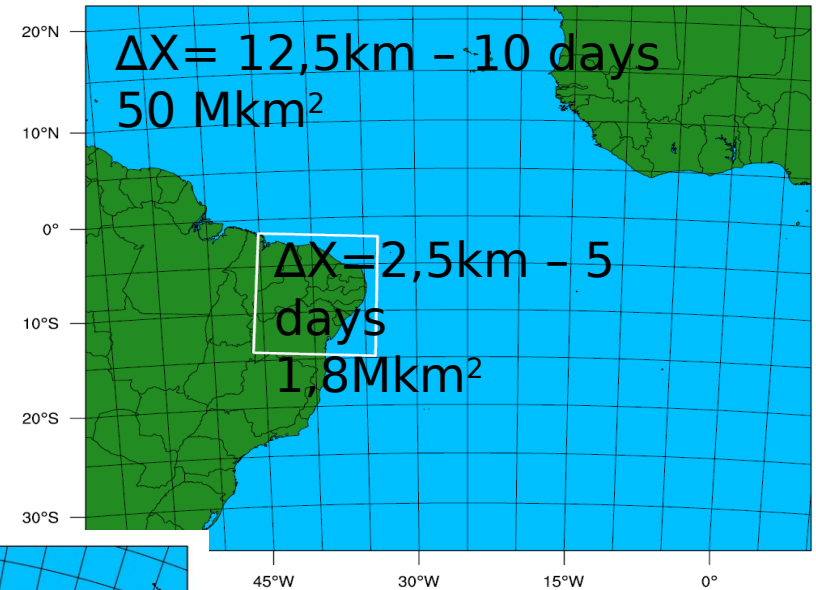
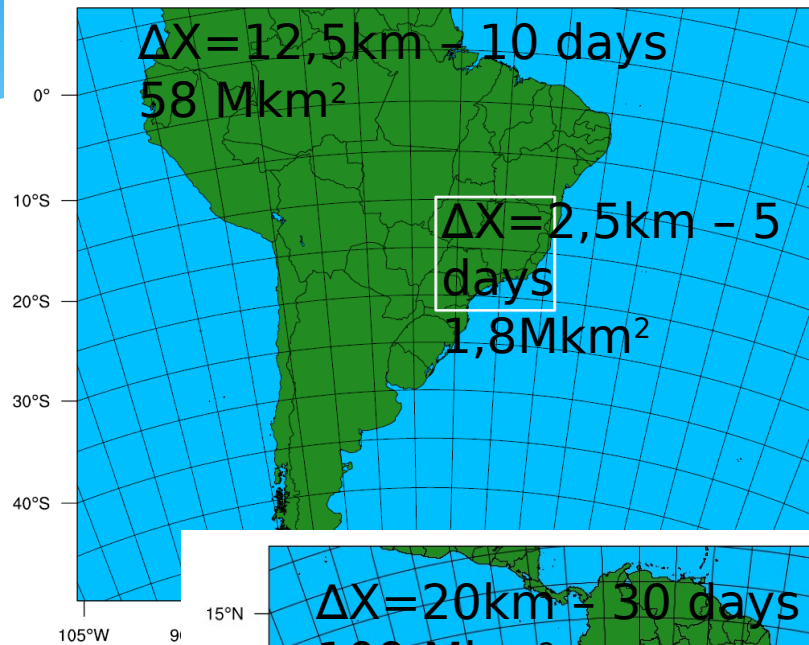
Where?



Where?



Where?

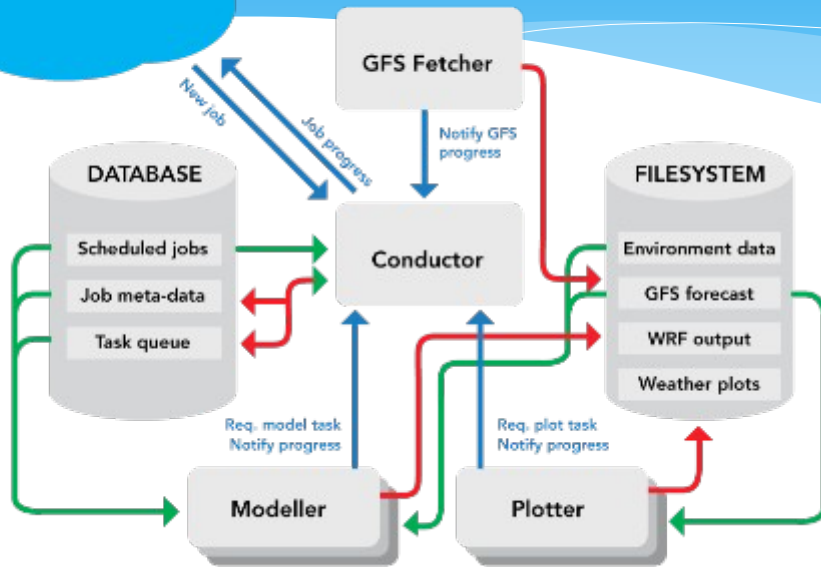


We operate three individual forecast regions, of which two have a nested inner domain. Forecast range is 5, 10, and 30 days

How?

The WOD forecasting system is run on an in-house cluster

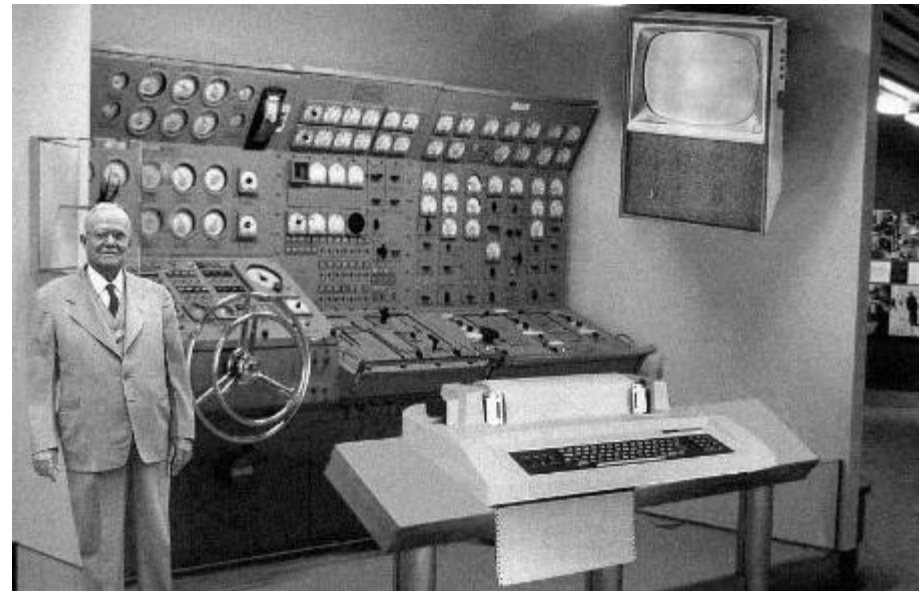
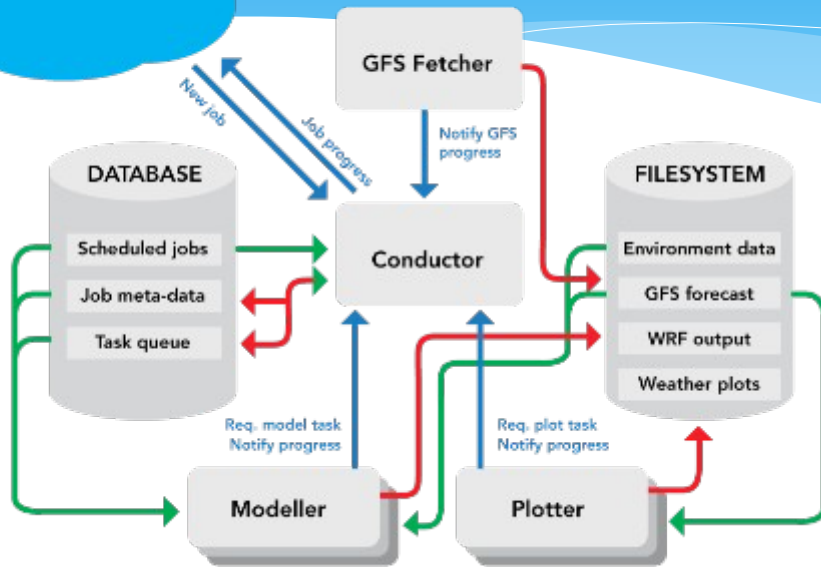
- Scalable
- Reliable
- Flexible



How?

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WOD description

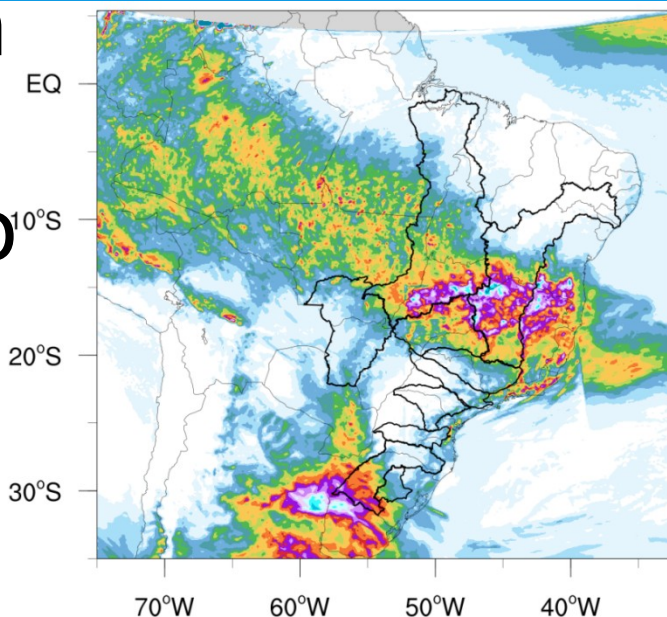
- * Built around the WRF-Chem modelling system
- * Initial and boundary data taken from the global GFS model as well as the GEFS and CFS systems
- * System installation is fast and highly automated
- * Can be used to create conventional short- to medium-range weather forecasts for any location on the globe as well as ensemble and S2S forecasts
 - * Input can be GFS, GEFS, and/or CFS
- * Can be used as a tool to provide input to other modelling systems, such as hydrological and agro-models
- * A wide variety of post-processing options are also available

Trade energy applications

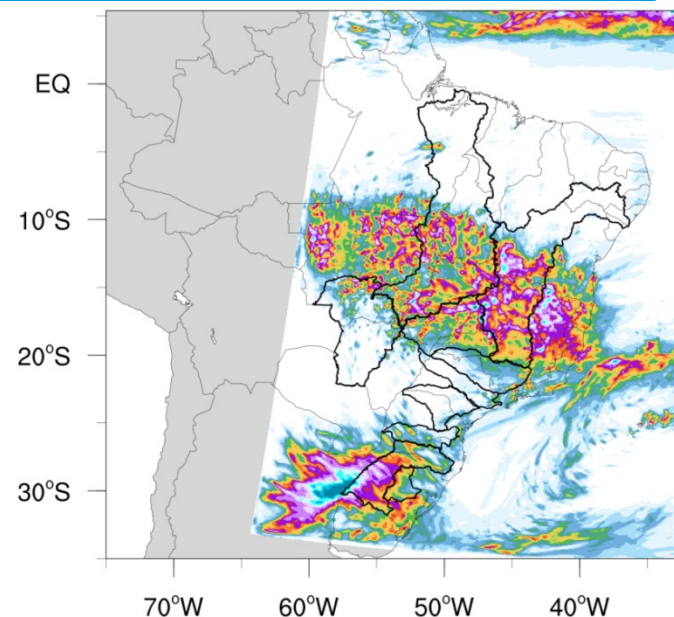
- * 64% of the Brazilian energy production comes from hydro-power
- * Monitoring the precipitation over the main hydrological basins is crucial in order to be able to estimate the energy pricing fluctuations
- * About 30% of the energy produced in Brazil is traded on the Free Market, where large companies can buy energy from traders who operate on the energy stock market
- * The energy prices in the Free Market fluctuates daily according to the energy available in the national system
- * The price, therefore, highly depends on weather conditions, since wind-, solar- and hydro-power sums over 72% of the Brazilian energy matrix

Operational model comparison

brazil-a



brazil-b

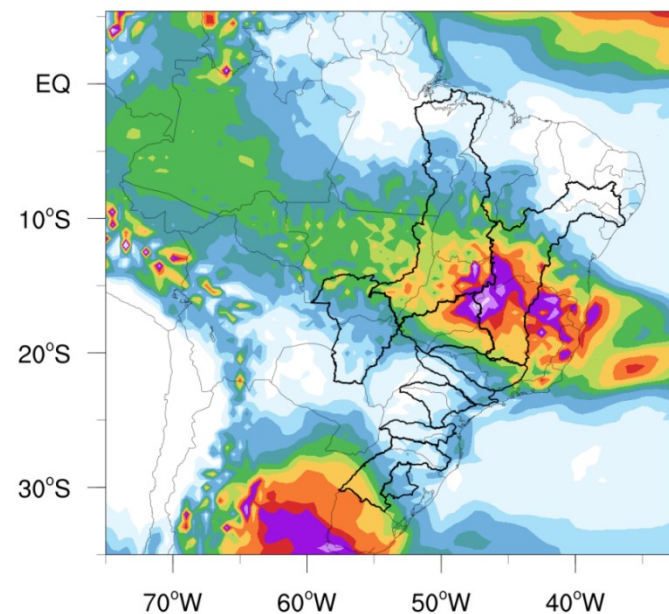
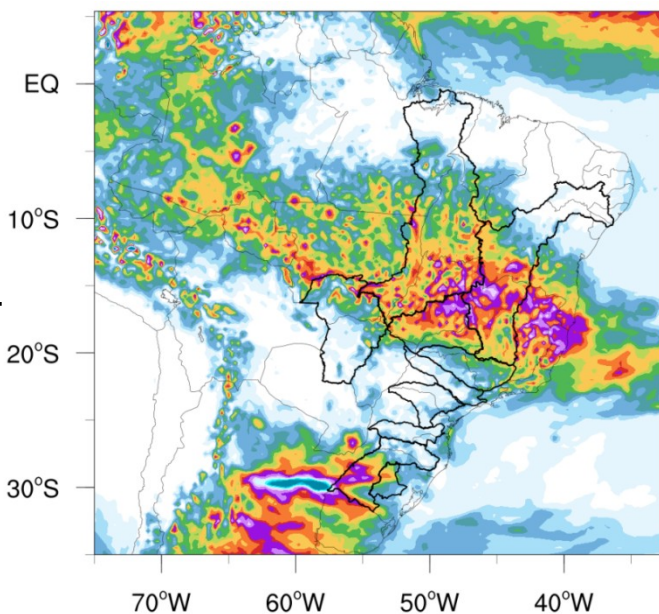


GFS

GEFS

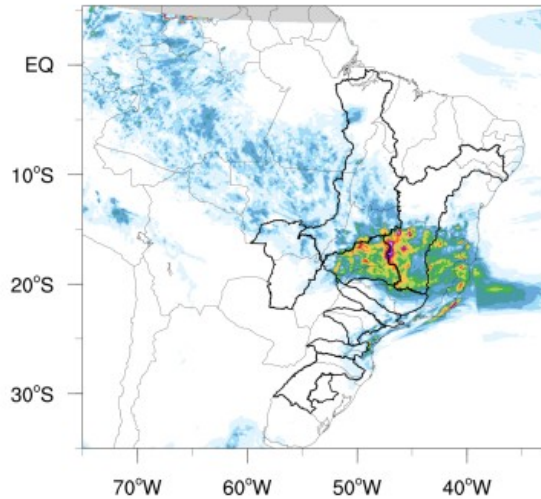
5-days accumulated precipitation in different basins

(both for days 1-5 and 6-10)

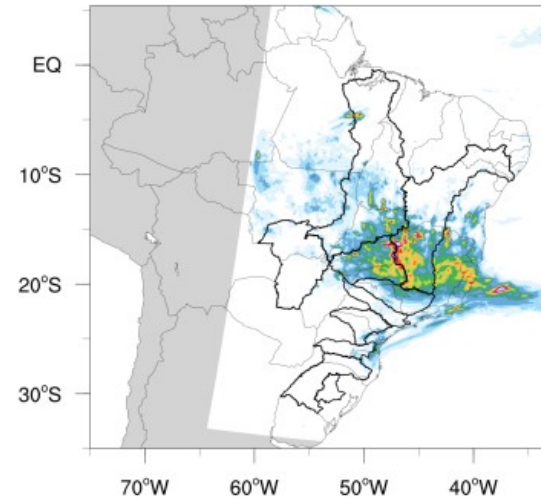


Also for daily precipitation up to 10 days

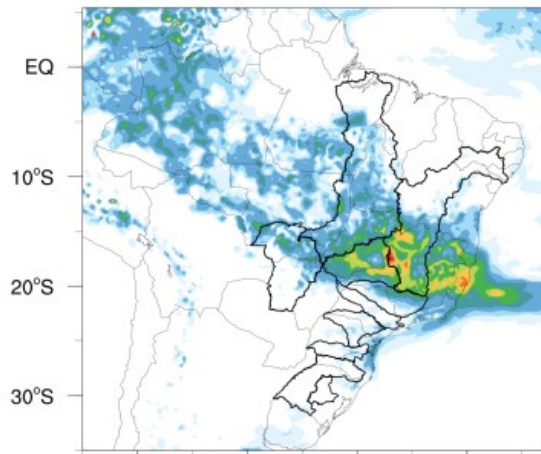
Previsão TOK-a para: 09-11-2018



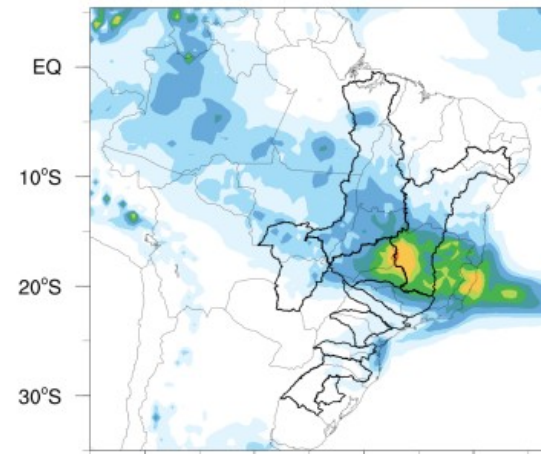
Previsão TOK-b para: 09-11-2018



Previsão GFS para: 09-11-2018



Previsão GEFS para: 09-11-2018



Objective values for model comparison per forecasted day or 5-days

Modelo	TOK-a			TOK-b			GFS			GEFS			ETA40		
	PM	EM	V	PM	EM	V	PM	EM	V	PM	EM	V	PM	EM	V
Bacia															
Alto Paraguai	14	9	7	14	6	3	21	4	1	18	4	0	13	11	8
Iguaçu	5	4	2	17	4	3	5	3	0	6	6	2	6	9	6
Jacuí	22	6	-5	47	7	-5	33	6	-4	15	7	-4	41	10	-3
Paranaíba	56	7	5	59	6	3	71	6	4	58	5	3	46	11	8
Paranapanema	4	4	3	2	3	2	4	3	2	5	5	3	6	11	9
Rio Grande	17	6	3	15	6	4	22	5	2	24	7	2	22	21	16
São Francisco	47	3	1	53	4	0	48	3	1	55	3	0	23	6	2
Tietê	6	5	4	4	5	4	7	4	3	9	5	5	8	16	15
Tocantins	34	4	3	36	3	0	43	3	1	35	2	-0	35	5	3
Uruguai	44	5	-3	85	5	-3	47	5	-3	22	7	-2	38	9	-2

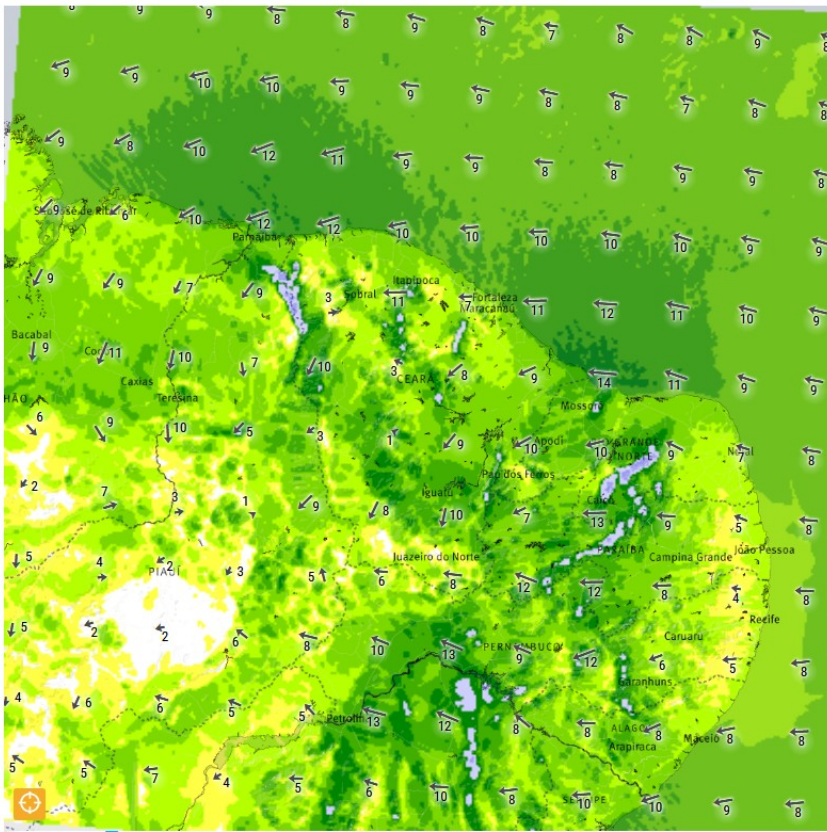
Wind power production

- * The wind mill cannot be erected if the wind speed exceeds 8 m/s, so precise wind forecast at different levels above the ground is important during the farm's installation and maintenance
- * Wind velocity, specially in tropical regions has strong diurnal and local variability (due to turbulence), so models with both high temporal and spatial resolutions are very important for wind power production forecast
- * In Brazil it is mandatory for wind power companies to report to the government the expected power production for the next 10 days
- * It is important for wind power companies short term strategic planning to estimate its power production, even though the energy pricing is fixed by long term contracts. Exceeding contracted energy production can be sold at the *Free Market*
- * Wind production is usually derived from wind speed, wind direction and air density estimated at the wind mill's hub level

Wind speed at hub height

NE-Brazil - Vento a 90m -

Qua, 5 de setembro às 22:00 GMT-3



time	wind_speed_at_90m_agl	solar_irradiance	prec_rate	temperature
2018-08-14T03:00:00	2,01	0	0,01	19,95
2018-08-14T04:00:00	2,13	0	0	18,62
2018-08-14T05:00:00	4,63	0	0	18,19
2018-08-14T06:00:00	3,28	0	0	19,47
2018-08-14T07:00:00	3,28	0	0,18	19,61
2018-08-14T08:00:00	2,95	0	0,01	18,16
2018-08-14T09:00:00	2,3	0	0	17,99
2018-08-14T10:00:00	0,59	567,21	0	20,11
2018-08-14T11:00:00	2,22	815,5	0	22,1
2018-08-14T12:00:00	3,3	1030,6	0	23,49
2018-08-14T13:00:00	2,75	1001,87	0	24,49
2018-08-14T14:00:00	2,4	1269,24	0	25,62
2018-08-14T15:00:00	3,43	1290,03	0	26,51
2018-08-14T16:00:00	3,02	1242,99	0	27,33

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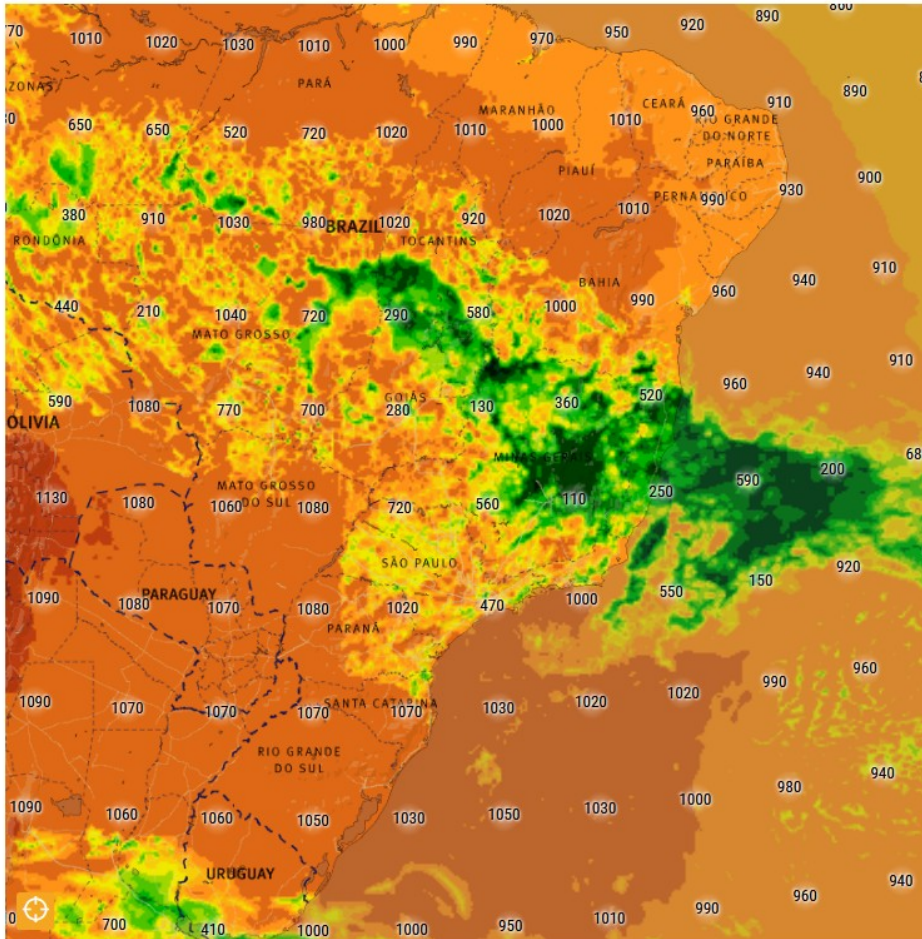
Solar power production

- * Solar farms are usually built in semi-desert regions where dust often covers instruments for irradiance data collection. A good 1-day weather forecast is an independent dataset to use for daily monitoring of irradiance
- * High temporal resolution of regional models output is very important for a precise production forecast
- * The solar power efficiency is a function of short wave downward irradiance, 2-m temperature and 10-m wind speed

Incoming solar irradiance

Brazil-a ▾ Irradiância solar ▾

Sáb, 10 de novembro às 14:00 GMT-2 ⓘ



# analysis_date: 2018-08-14T00:00:00				
# latitude: -14.865				
# longitude: -39.676				
time	wind_speed_at_90m_agl	solar_irradiance	prec_rate	temperature
2018-08-14T03:00:00	2,01	0	0,01	19,95
2018-08-14T04:00:00	2,13	0	0	18,62
2018-08-14T05:00:00	4,63	0	0	18,19
2018-08-14T06:00:00	3,28	0	0	19,47
2018-08-14T07:00:00	3,28	0	0,18	19,61
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2018-08-14T10:00:00	0,59	567,21	0	20,11
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2018-08-14T14:00:00	2,4	1269,24	0	25,62
2018-08-14T15:00:00	3,43	1290,03	0	26,51
2018-08-14T16:00:00	3,02	1242,99	0	27,33

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Brazilian energy companies currently using our forecast solutions



Heimsyfírráð, eða kvef !!

Thank you

BRACE YOURSELF

