WORLD BANK GROUP
Energy & Extractives

R2E2
ARMENIA RENEWABLE RESOURCES AND ENERGY EFFICIENCY FUND

2 The Project. Task 3: Ground-based data collection

2. The Project. Task 3: Ground-based data collection

Implementation Plan

Items accomplished

- Obtaining all the permitting and licenses, including authorization to perform civil works, land use and environmental licenses (if required).
- The preparation of the sites (planning and design) and civil works
- In-country storage and transportation
- Equipment installation and commissioning on site
- Operation and Maintenance tasks
- Site security
- Data transmissions and communications fees
- Others fees as rent and land acquisition.

Measurement Campaign started at mid May 2016 (~4 months later)

2. The Project. Task 3: Ground-based data collection

The Stations

Description of instruments

- **Tracker** - Model SunTracker-3000, Model SP-360
- **Pyrheliometer** - Model GEO-DR02
- **Pyranometer** - Model GEO-SR20, Model SP-101
- **Sun photometer** - Model GEO-SolarSIM-D2
- **Shading ring** - Model SA-3000
- **Data Logger** - Model METEODATA-3016CM, Option VT alphanumeric display (LCD), Option ACM-3000
- **Power Supply** - Autonomous Power supply system for the automatic weather Station
- **Power heater** - Model VEN
- **Location, time/date info & setup** - Option GPS
- **Mounting hardware** - Model TM-180-03
- **Communication** - Option Ethernet, Option High-Gain, Option GPRS-IP, Option VipService-4K
- **Wind speed and wind direction sensor** - Model 03002 Wind Sentry
- **Barometric pressure sensor** - Model 61302V, Model 61360
- **Temperature and relative humidity** - Model STH-S331, Model 41003
- **Rain level gage** - Model 52203-20, Model SPL-5200
- **Surface temperature sensor** - Model 285-PT100

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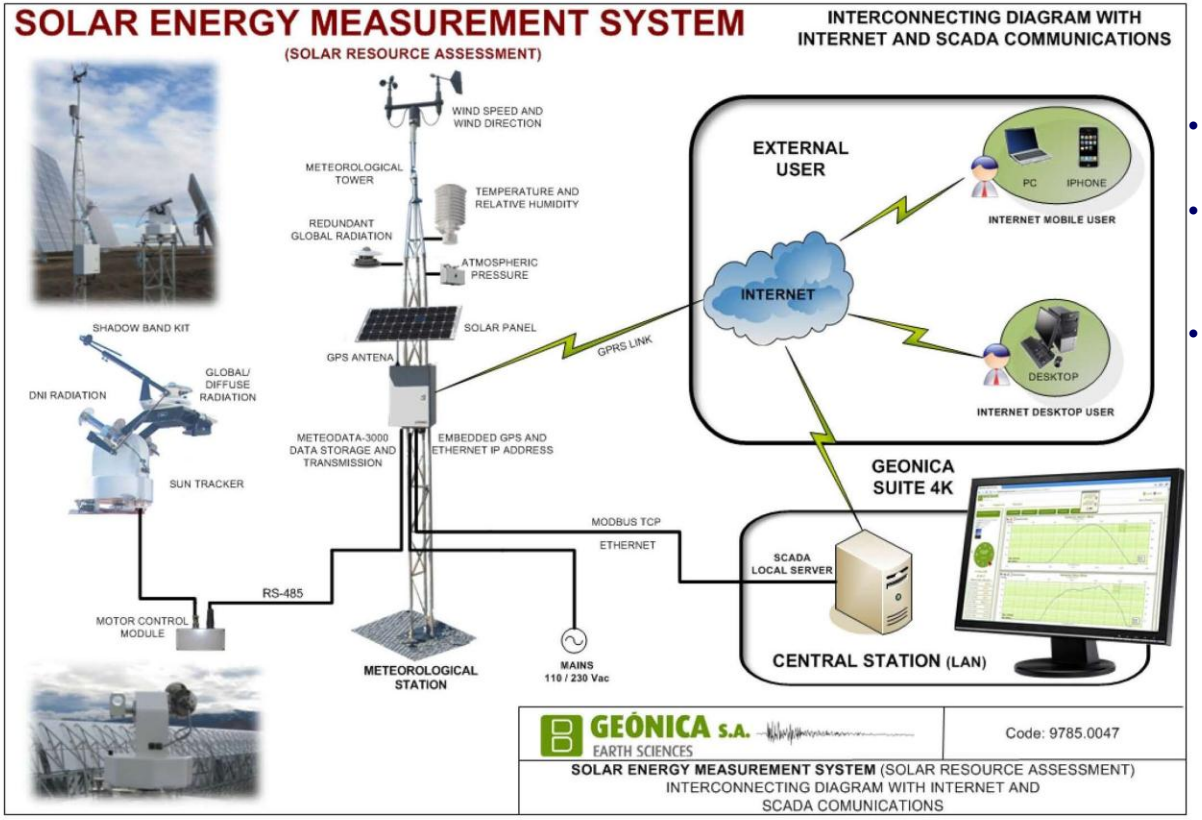
The Stations



Physical Magnitudes to be measured

- Solar radiation components: GHI, DNI, DHI, GTI
- Meteorological parameters: pressure, temperature, wind, reltive humidity, precipitation
- Aerosol optical depth (spectral)

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The measurement campaign: Operation and Maintenance

Daily/Weekly Tasks

- Cleaning from dust, ice, condensation, adhered matter
- Levelling, pointing, tracking
- Cabling, Power, Data acquisition system
- **Data Quality Analysis** (4 specific quarterly reports)

Long-term (annual/semi-annual) Tasks

- Status of electrical connections, power, tracking.
- Calibration

Additional independent check

- Report Lara-Fanego, 2016: Physical inspection and data analysis

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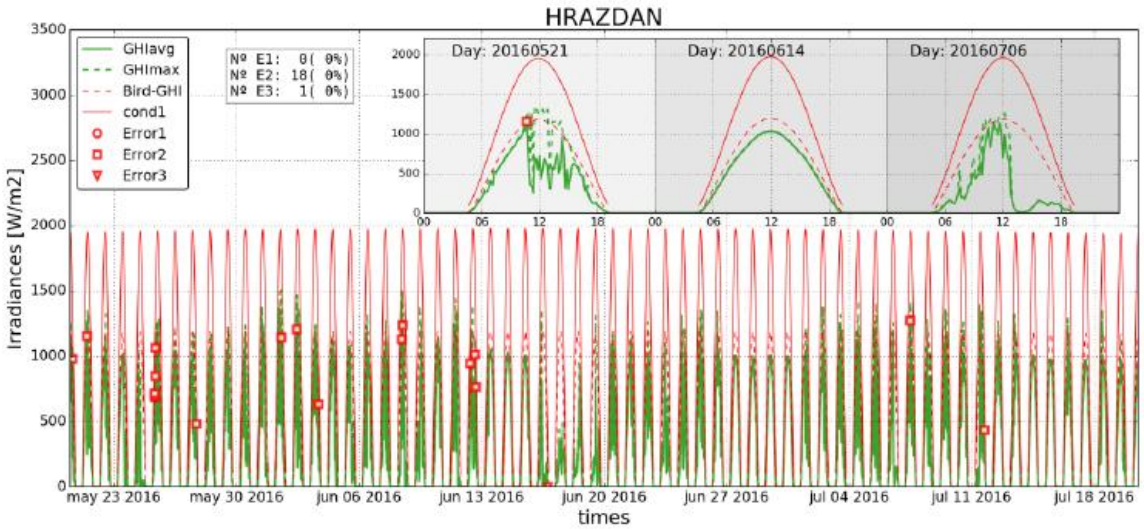
The measurement campaign: Independent inspection

Aditional independent check

- Report Lara-Fanego, 2016: Physical inspection and data analysis
- Stations of high quality



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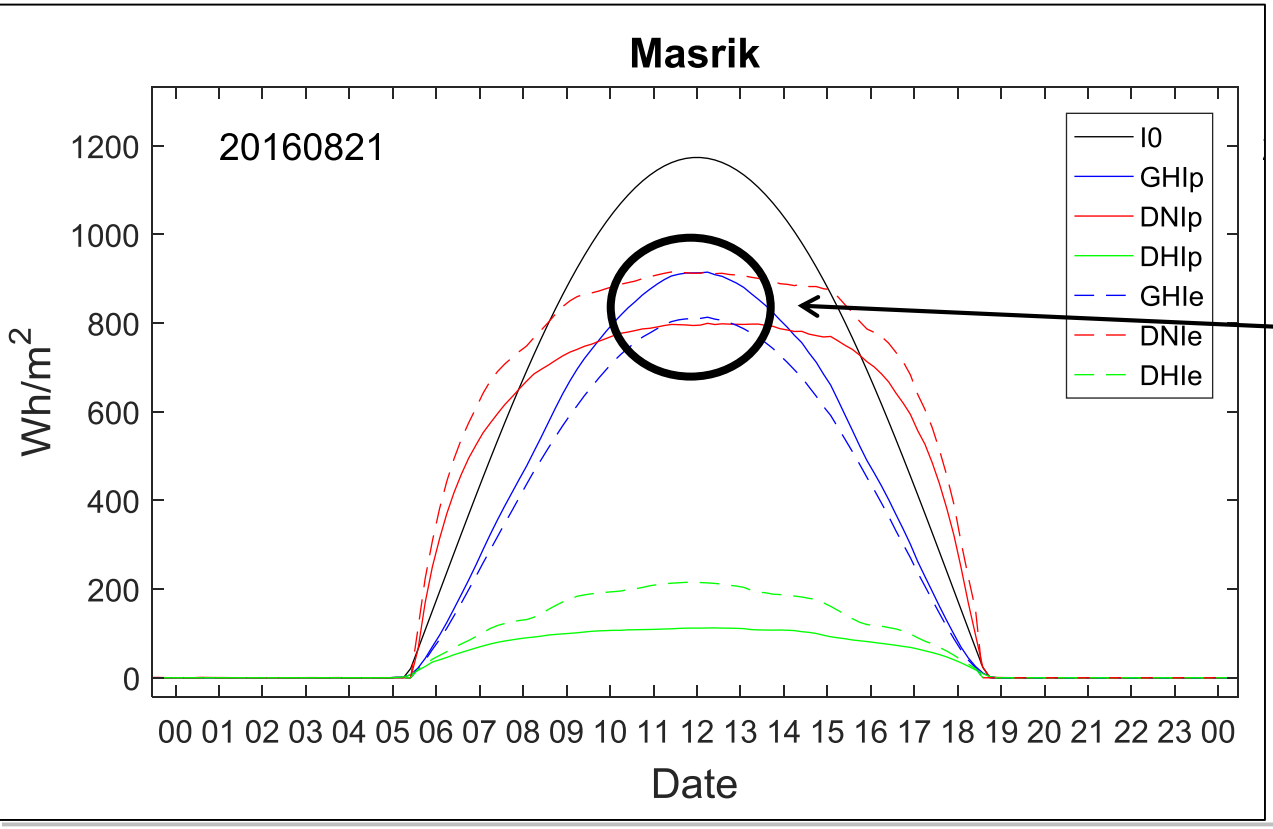
The measurement campaign: Data Quality Analysis



Visual Inspection

Experienced eye: pyrheliometer misalignment

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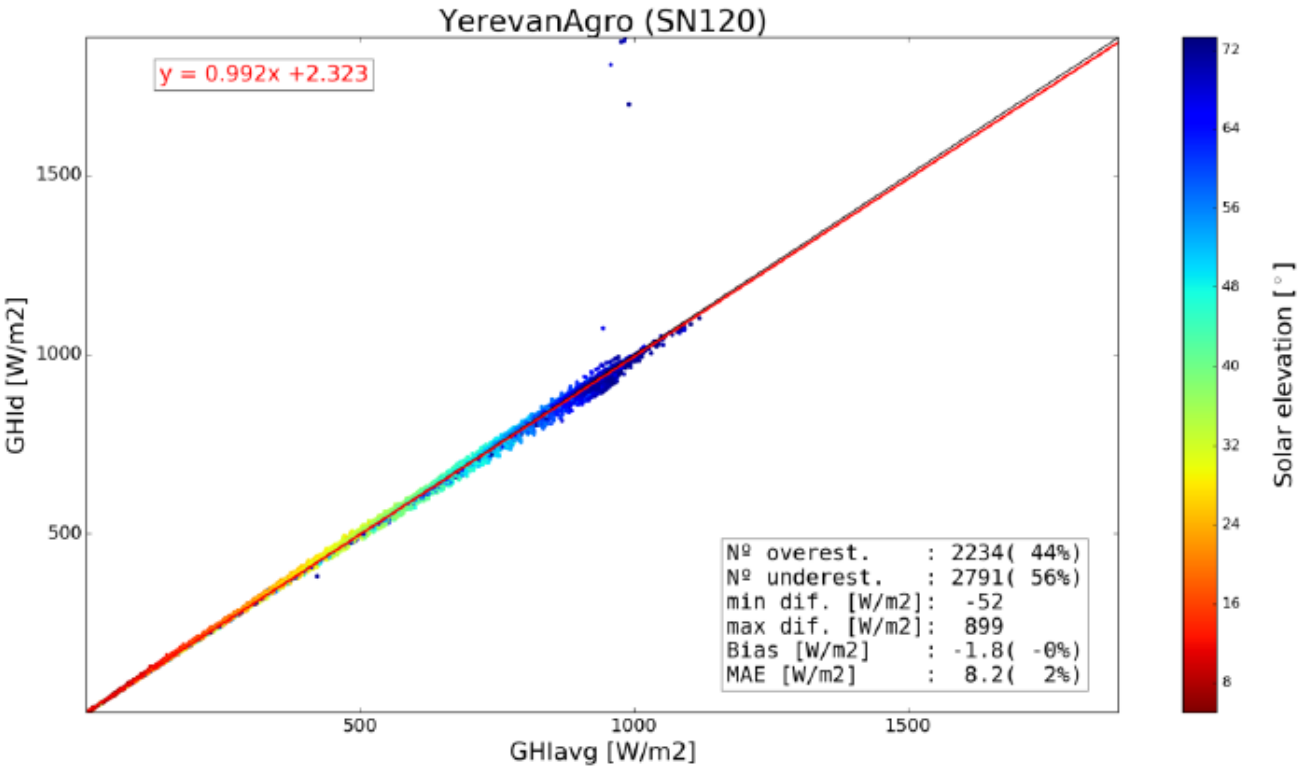
The measurement campaign: Data Quality Analysis



Visual Inspection

Experienced eye: coherence between redundant measurements

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The measurement campaign: Data Quality Analysis

Automatic tests

"Physically Possible"

Parameter	Minimum	Flag for Minimum	Maximum
Global Horizontal Irradiance (GHI)	-4	2	$I_{SC}\,\varepsilon 1.5(\cos\theta_z)^{1.2}+100\,W/m^2$
Diffuse Horizontal Irradiance (DIF)	-	-	700 W/m^2
Diffuse Horizontal Irradiance (DIF)	-4	2	$I_{SC}\,\varepsilon 0.95(\cos\theta_z)^{1.2}+50\,W/m^2$
Direct Normal Irradiance (DNI)	-4	2	$I_{SC}\,\varepsilon$
Direct Normal Irradiance (DNI)	-	-	DNI Clear Sky (B_{cs})

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The measurement campaign: Data Quality Analysis

Automatic tests

"Across Quantities"

Parameter	Conditions	Limits
$\frac{GHI}{DIF + DNI\cos\theta_z}$	$\theta_z < 75^o,\ DIF + DNI\cos\theta_z > 50\,W/m^2$	1 ± 8%
$\frac{GHI}{DIF + DNI\cos\theta_z}$	$75^o < \theta_z < 93^o,\ DIF + DNI\cos\theta_z > 50\,W/m^2$	1 ± 15%
$\frac{DIF}{GHI}$	$\theta_z < 75^o,\ GHI > 50\,W/m^2$	< 1.05
$\frac{DIF}{GHI}$	$75^o < \theta_z < 93^o,\ GHI > 50\,W/m^2$	< 1.10

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The measurement campaign: Data Quality Analysis

Automatic tests

"Extremely Rare"

Parameter	Lower Limit	Upper Limit
$DNI \cdot \cos\theta_z$	$(GHI-DIF)-50\ W/m^{-2}$	$(GHI-DIF)+50\ W/m^{-2}$
$GHI-DIF$	$DNI\cos\theta_z - 50\ W/m^{-2}$	$DNI\cos\theta_z + 50\ W/m^{-2}$

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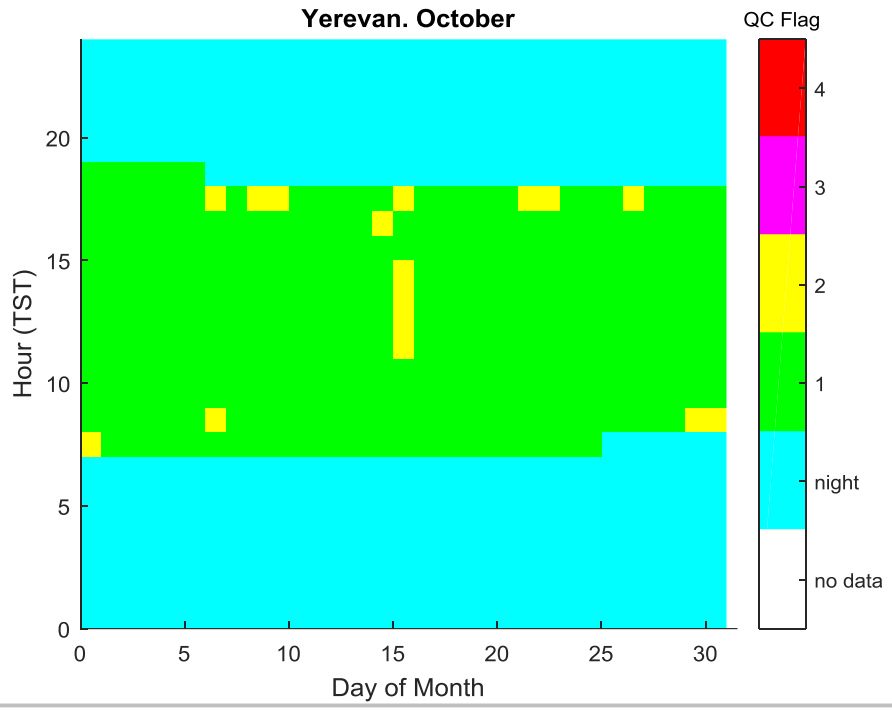
The measurement campaign: Data Quality Analysis

Automatic tests



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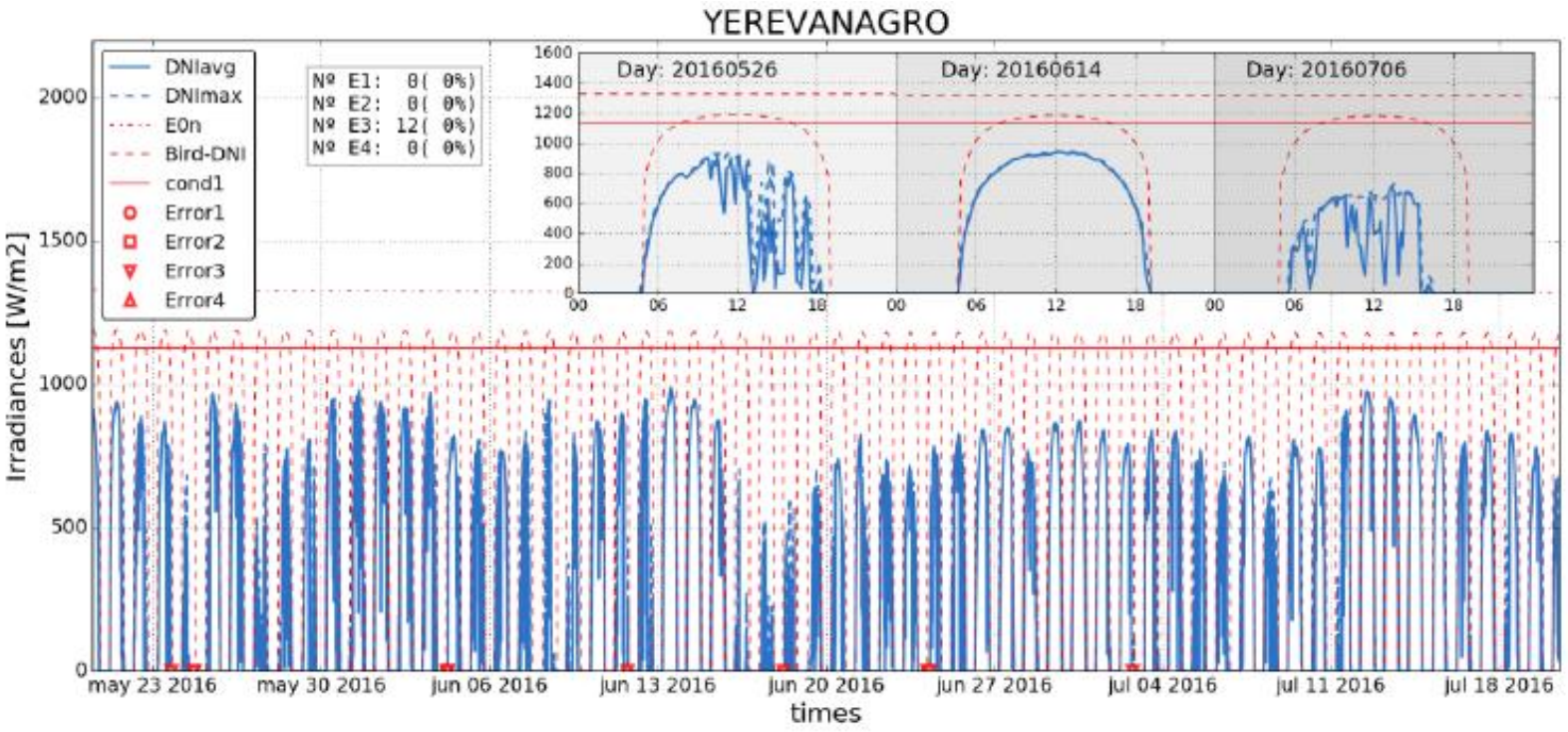
The measurement campaign: Data Quality Analysis

Automatic tests



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The measurement campaign: Data Quality Analysis

Automatic tests

Station	Flag 1	Flag 2	Flag 3	Flag 4
	Data ok	Fail Cross-Component Test	Fail Extremely Rare Range Test	Fail Physically Possible Range Test
Hrazdan	96.1%	3.9%	0%	0%
Masrik	79.4%	20.6%	0%	0%
Yerevan	96.7%	3.3%	0%	0%
Talin	91.7%	9.3%	0%	0%

Main features: pyrheliometer misalignments.

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The measurement campaign

Note about Khot station

- Proposed at the final part of the proyect
- Not the same period of measurements
- Not the same variables
- Not included in the preliminary study of site selection
- Finally not included in the map correction
- Quality analysis performed: good results, but limited because of the reduced number of method that can be applied

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The measurement campaign

Initial study for optimizing station locations:

- D7. Candidate site identification report (clustering)
- D11. Advice on site selection report

Four quarterly reports on data quality analysis

- D17.Quarterly site resource report (Q1, Q2, Q3, Q4)

Main conclusions

- Stations of high quality. Data are of great value for solar resource assessment in Armenia
- Requiere proper performance of O&M activities (cleaning, aligning, callibration, data quality control)
- Data issues detected are indentified and controled. They were also corrected when possible.
- Redundat measurements allow maintaning temporal homogenity by gaps filling. They are also fundamental for quality check.

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