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## AirMOSS: L4 Modeled Volumetric Root Zone Soil Moisture, 2012-2015

### Get Data

Documentation Revision Date: 2016-12-14

Data Set Version: V1

### Summary

This data set provides hourly gridded soil moisture estimates derived from hydrologic modeling at nine AirMOSS sites across North America. The AirMOSS L4 RZSM product represents a temporal interpolation of intermittent AirMOSS L2/3 RZSM retrievals into a temporally-continuous, multi-layer, hourly soil moisture product. The L4 RZSM data have the same spatial resolution (3-arcsecs or ~100 m), and the same temporal coverage (generally Fall 2012 through Fall 2015), as the underlying L2/3 RZSM data. The L4 RZSM data were produced by the integration of the Level 2/3 product and other ancillary information into the Penn State Integrated Hydrologic Model (PIHM). Many key applications for AirMOSS data products, including the calculation of net ecosystem exchange (NEE), require temporally continuous RZSM estimates such as those provided here.

This data set includes 7603 files in netCDF (\*.nc4) format. The algorithm theoretical basis document (ATBD) for this data product is included as a companion file.

## Metolius site, Oregon on February 25, 2014

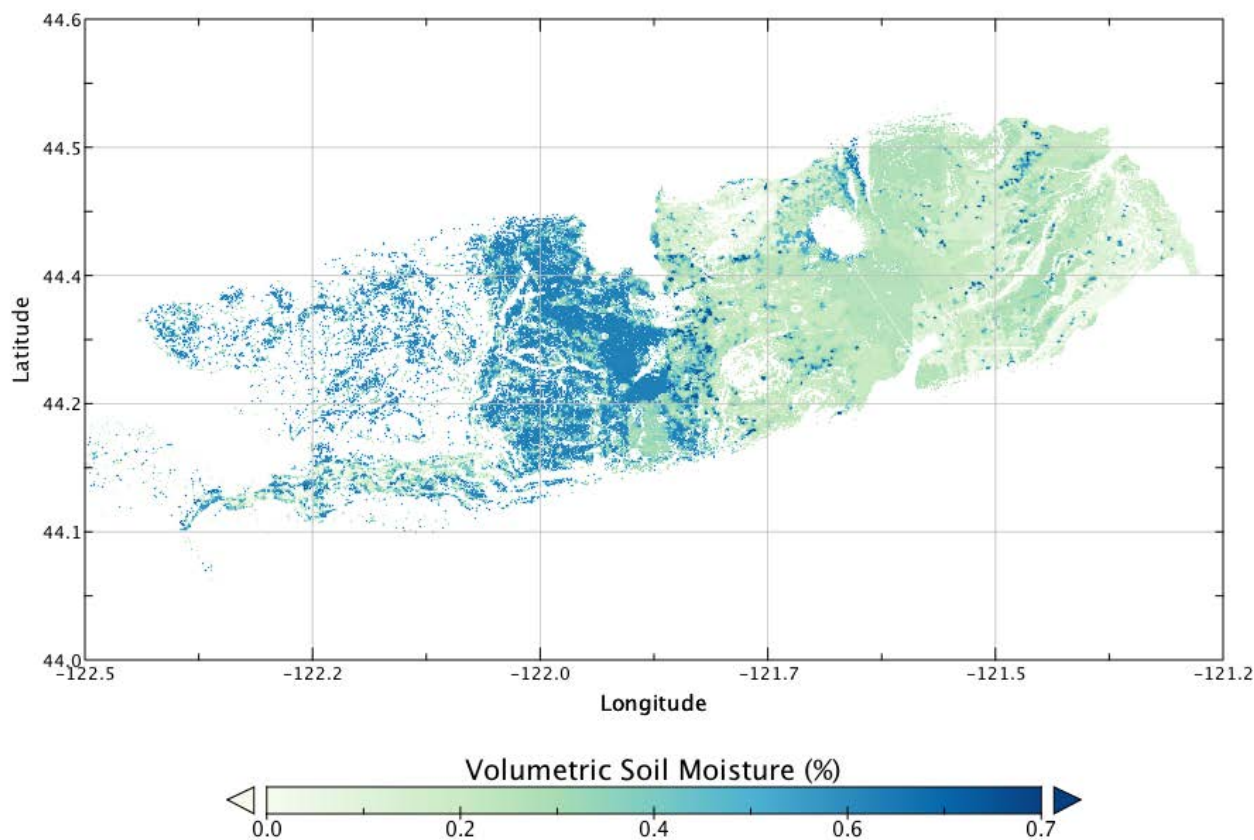


Figure 1: Modeled surface (0 - 10 cm) soil moisture at the Metolius site, Oregon, at midnight on Feb. 25, 2014.

## Citation

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## 1. Data Set Overview

This data set provides hourly gridded soil moisture estimates derived from hydrologic modeling at nine AirMOSS sites across North America. The AirMOSS L4 RZSM product represents a temporal interpolation of intermittent AirMOSS L2/3 RZSM retrievals into a temporally-continuous, multi-layer, hourly soil moisture product. The L4 RZSM data have the same spatial resolution (3-arcsecs or ~100 m), and the same temporal coverage (generally Fall 2012 through Fall 2015), as the underlying L2/3 RZSM data. The L4 RZSM data were produced by the integration of the Level 2/3 product and other ancillary information into the Penn State Integrated Hydrologic Model (PIHM). Many key applications for AirMOSS data products, including the calculation of net ecosystem exchange (NEE), require temporally continuous RZSM estimates such as those provided here.

**Project:** [Airborne Microwave Observatory of Subcanopy and Subsurface \(AirMOSS\)](#)

The goal of NASA's Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) investigation is to provide high-resolution observations of root-zone soil moisture over regions representative of the major North American climatic habitats (biomes), quantify the impact of variations in soil moisture on the estimation of regional carbon fluxes, and extrapolate the reduced-uncertainty estimates of regional carbon fluxes to the continental scale

of North America.

- The AirMOSS campaign used an airborne ultra-high frequency synthetic aperture radar flown on a Gulfstream-III aircraft to derive estimates of soil moisture down to approximately 1.2 meters.
- Extensive ground, tower, and aircraft in-situ measurements were collected to validate root-zone soil measurements and carbon flux model estimates.

The AirMOSS soil measurements can be used to better understand carbon fluxes and their associated uncertainties on a continental scale. Additionally, AirMOSS data provide a direct means for validating root-zone soil measurement algorithms from the Soil Moisture Active & Passive (SMAP) mission and assessing the impact of fine-scale heterogeneities in its coarse-resolution products.

#### Related Data:

The following AirMOSS data were directly used to generate this data:

Moghaddam, M., A. Tabatabaeenejad, R.H. Chen, S.S. Saatchi, S. Jaruwatanadilok, M. Burgin, X. Duan, and M.L. Truong-Loi. 2016. AirMOSS: L2/3 Volumetric Soil Moisture Profiles Derived From Radar, 2012-2015. ORNL DAAC, Oak Ridge, Tennessee, USA.

<http://dx.doi.org/10.3334/ORNLDAAC/1418>

A full list of AirMOSS data products is available at: <https://airmoss.ornl.gov/dataproducts.html>.

## 2. Data Characteristics

**Spatial Coverage:** Nine AirMOSS sites across North America

**Spatial Resolution:** 100 meters

**Temporal Coverage:** 20120921 to 20150928. Coverage at individual sites is provided in Table 1.

**Temporal Resolution:** Hourly

**Study Area** (coordinates in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
North America	-123.28	-68.124	54.125	19.125

**Table 1.** AirMOSS sites. Note that L4 RZSM data were not produced for the La Selva, Costa Rica site.

Site name	North latitude	South latitude	East longitude	West longitude	L4 RZSM date range	Fluxnet Site ID	Description
BermsP	54.125	53.501	-103.626	-107.125	20121025 to 20150927	CA-Ojp & CA-Oas	BERMS (Boreal Ecosystem Research and Monitoring Sites), Saskatchewan, Canada. Landcover: Mixed boreal forest. Elevation: 518m.
Chamel	20.326	19.316	-104.22	-105.29	20130616 to 20150414	MX-Cha	Chamela Biological Station, Jalisco, Mexico. Landcover: Seasonally dry tropical forest. Elevation: 58m.
DukeFr	36.368	35.437	-78.694	-79.849	20121014 to 20130823	US-Dk1, US-Dk2, US-Dk3	Duke Forest site, North Carolina, USA. Landcover: Mature oak-hickory dominated hardwood forest. Elevation: 169m.
Harvrd	43.376	42.293	-71.839	-72.389	20121016 to 20150908	US-Ha1 & US-Ha2	Harvard Forest site, Massachusetts, USA. Landcover: Temperate deciduous forest. Elevation: 353m.
Howlnd	45.778	44.669	-68.336	-69.086	20121016 to 20150908	US-Ho1, US-Ho2,	Howland Forest site, Maine, USA. Landcover: boreal - northern hardwood transitional forest. Elevation 72m.

						US-Ho3	
LaSelv	10.878	9.92	-83.519	-84.57	none	CR-Lse	La Selva Biological Station, Costa Rica. Landcover: tropical rain forest. Elevation 93m.
Metoli	45.242	43.38	-120.363	-123.283	20121014 to 20150928	US-Me1 to US-Me6	Metolius site, Oregon, USA. Landcover: evergreen needleleaf forest. Elevation 1237m.
Moisst	36.880	35.775	-96.824	-98.996	20121025 to 20150812	US-ARM	The Marena, Oklahoma In Situ Sensor Testbed (MOISST) is located in Oklahoma, USA. Landcover: temperate grasslands, crops. Elevation: 312m.
TonziR	38.625	37.501	-120.001	-121.25	20131025 to 20150530	US-Ton	Tonzi Ranch site, California, USA. Landcover: oak savanna and grazed grassland. Elevation 170m.
Walnut	32.125	31.501	-109.376	-111.5	20120921 to 20150831	US-Wkg & US-Whs	Walnut Gulch site, Arizona, USA. Landcover: warm season C4 grassland with a few shrubs. Elevation 1524m.

### Data File Information

This data set includes 7603 files in netCDF (\*.nc4) format. Each file represents one day at one site and contains 24 data layers, one for each hour of the day. The algorithm theoretical basis document (ATBD) for this data product is included as a companion file (*L4RZSM\_ATBD\_V10.pdf*).

### File naming convention

AirMOSS L4 RZSM data file names have the format: *L4RZSM\_ssssss\_yyyymmdd\_vv.nc4*

where: ssssss = site name; yyyymmdd = date; vv = version number. All sites except DukeFr are version 5.

**Table 2.** Data fields in the L4 RZSM data files. Missing data are represented by -9999.

Data Field	Units	Description
<b>browse</b>	vol / vol	Browse layer. Gridded soil moisture for the surface layer (sm1) at the last hour of the day.
<b>lat</b>	degrees North	Latitude of grid cell
<b>lon</b>	degrees East	Longitude of grid cell
<b>sm1</b>	vol / vol	Gridded hourly soil moisture at depth 0-10 cm.
<b>sm2</b>	vol / vol	Gridded hourly soil moisture at depth 10-40 cm.
<b>sm3</b>	vol / vol	Gridded hourly soil moisture at depth 40 – 100 cm.

<b>sm4</b>	vol /vol	Gridded hourly soil moisture at depth 100 - 200 cm. <i>Not all sites and dates have sm4 data.</i>
<b>time</b>	Hours since 2010-01-01 00:00:00 UTC	Date and hour of modeled output. Each file contains only one day (24 hours) of data.

**Incomplete Data Notes:**

Data files are not available for the following sites and dates:

**Moisst:** 20140109, 20140124, 20140204, 20140210, 20140214, 20140225, 20140302, 20140301, 20140315, 20140320, 20140324, 20140403, 20140404, 20140405, 20140407, 20140420, 20140421, 20140503, 20140504, 20140522, 20140612, 20140622, 20140801, 20140812, 20140813, 20140827, 20140829, 20140926, 20140927, 20141012, 20141023, 20141028, 20141106, 20141112, 20141115, 20141118, 20141127, 20141210, 20141230, 20141231

**Harvrd:** 20130101-20130823, 20130830, 20130831, 20140824

**TonziR:** 20140710, 20140712, 20140824

Data files for the following sites and dates contain only 'no-data' values:

**Howland:** 20121231-20130831

**TonziR:** 20140916-20141021, 20141127-20150102, 20150209-20150316, 20150424-20150528

### 3. Application and Derivation

The AirMOSS data products and expected science results are tailored to meet the need to reduce uncertainty in estimates of net ecosystem exchange (NEE) through the development of methodologies to integrate remote sensing observations, in-ground soil sensors, and flux tower data into regional/continental flux models. Additionally, AirMOSS data provide a direct means for evaluating RZSM algorithms of the SMAP Decadal Survey mission and assessing the impact of fine-scale heterogeneities in its coarse-resolution products.

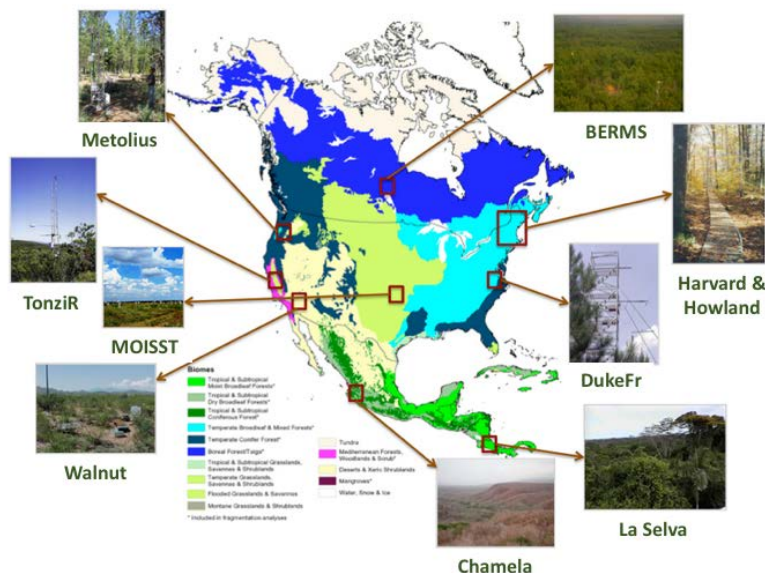
### 4. Quality Assessment

The hydrologic model at the core of the L4 RZSM algorithm requires a diverse set of soil, geologic and vegetation parameters to accurately capture the flux and storage of water within (and out of) a hydrologic catchment. Failure to accurately specify these parameters can degrade the accuracy of model predictions. While all efforts will be made to minimize calibration error by considering all available stream flow and soil hydraulic property information, model calibration errors will likely persist and impact the accuracy of L4 RZSM estimates.

Product error estimates are derived via the comparison of L4 RZSM algorithm output with independent, ground-based soil moisture observations acquired within individual AirMOSS study sites. Error estimates are shown in the ATBD document for this data product.

### 5. Data Acquisition, Materials, and Methods

The goal of the Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) investigation is to provide high-resolution observations of root-zone soil moisture over regions representative of the major North American climatic habitats (biomes), quantify the impact of variations in soil moisture on the estimation of regional carbon fluxes, and extrapolate the reduced-uncertainty estimates of regional carbon fluxes to the continental scale of North America.



**Figure 2.** AirMOSS study sites were co-located with flux towers in nine different biomes across North America.

### AirMOSS Flights

For AirMOSS, NASA's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) was flown on a Gulfstream-III aircraft, making frequent flights over ten sites (Table 1 and Figure 2) in 9 different biomes of North America over the course of four years (Chapin et al. 2012).

Beginning in September 2012, the AirMOSS instrument flew 215 flight campaigns. A summary of flight campaigns by year and site is found in Table 3. Typically, the aircraft made repeat visits to sites in the same region in a single week and then proceeded to another region. Most sites had at least three campaigns per year. The Harvard and Howland forest sites were flown together in a single day. In 2012, Chamela, La Selva, and Tonzir were not surveyed.

**Table 3.** Summary of AirMOSS flight campaigns.

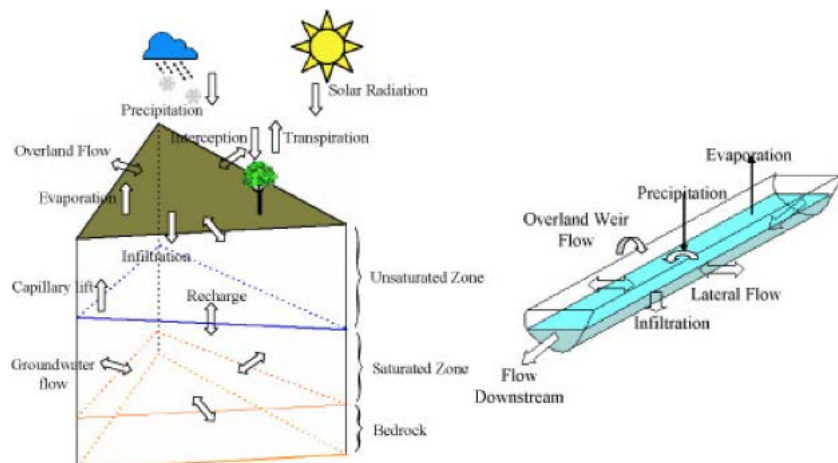
	Site									
Year	BermsP	Chamel	DukeFr	Harvrd	HowInd	LaSelv	Metoli	Oklaho	Tonzir	Walnut
2012	3	0	3	3	3	0	4	3	0	3
2013	6	3	9	9	9	6	7	8	5	6
2014	7	3	10	9	9	3	9	9	6	5
2015	9	2	5	5	5	3	9	6	5	6
<b>Total</b>	25	8	27	26	26	12	29	26	16	20

A complete list of AirMOSS flights can be found at: <https://airmoss.ornl.gov/flights.html>.

### AirMOSS Level 4 Root Zone Soil Moisture Data Product

The objective of the AirMOSS L4 RZSM algorithm is the realistic temporal interpolation of intermittent AirMOSS L2/3 RZSM retrievals into a temporally-

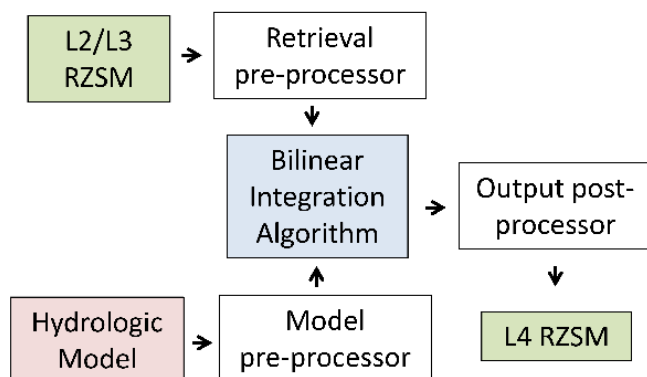
continuous, multi-layer, hourly soil moisture product. For information about L2/3 RZSM, see Moghaddam et al. (2016; <http://dx.doi.org/10.3334/ORNLDAAC/1418>). The L4 RZSM algorithm is based on the Penn State Integrated Hydrologic Model (PIHM; Figure 3) that makes continuous predictions about the evolution of soil moisture states in response meteorological drivers such as rainfall and incident radiation [Qu and Duffy, 2007; Yu et al., 2014].



**Figure 3.** Schematic of physical processes represented in the Penn State Integrated Hydrologic Model (PIHM).

As illustrated in Figure 4 below, the L4 RZSM algorithm consists of three components:

- (1) a hydrologic model, PIHM,
- (2) a bilinear integration procedure, where AirMOSS L2/3 RZSM data is integrated with the PIHM output,
- (3) and pre- and post-processing stages required to transform RZSM products between specified AirMOSS project formats and the format requirements of the hydrologic model.



**Figure 4.** Schematic of the AirMOSS L4 RZSM processing system.

The integration of AirMOSS L2/3 RZSM retrievals in the PIHM model was based on a relatively simple bilinear-interpolation integration approach. Figure 5 provides a graphical example for a single PIHM soil layer. More details of algorithm implementation are given in the ATBD for this product.



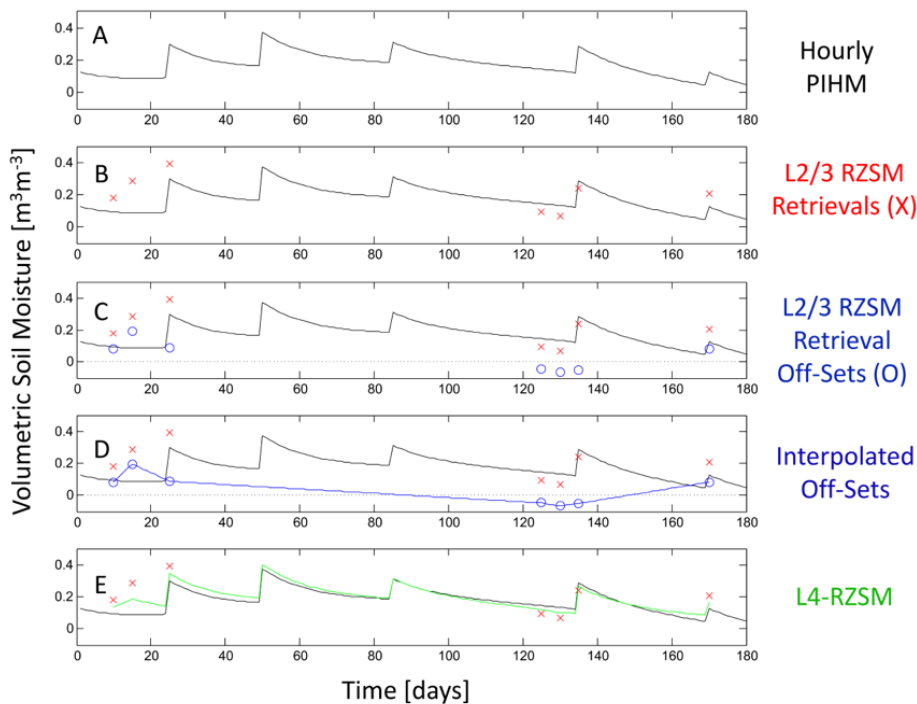


Figure 5. Example of the bilinear integration of AirMOSS L2/3 data with PIHM to produce L4 RZSM.

## 6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[AirMOSS: L4 Modeled Volumetric Root Zone Soil Moisture, 2012-2015](#)

Contact for Data Center Access Information:

- E-mail: [uso@daac.ornl.gov](mailto:uso@daac.ornl.gov)
- Telephone: +1 (865) 241-3952

## 7. References

Chapin, E., A. Chau, J. Chen, B. Heavey, S. Hensley, Y. Lou, R. Machuzak, and M. Moghaddam. 2012. AirMOSS: An Airborne P-band SAR to measure root-zone soil moisture, 2012 *IEEE Radar Conference*, Atlanta, GA, 2012, pp. 0693-0698. <http://dx.doi.org/10.1109/RADAR.2012.6212227>

Moghaddam, M., A. Tabatabaenejad, R.H. Chen, S.S. Saatchi, S. Jaruwatanadilok, M. Burgin, X. Duan, and M.L. Truong-Loi. 2016. AirMOSS: L2/3 Volumetric Soil Moisture Profiles Derived From Radar, 2012-2015. ORNL DAAC, Oak Ridge, Tennessee, USA. <http://dx.doi.org/10.3334/ORNLDAAC/1418>

Qu, Y., and Duffy, C.J. (2007) A semidiscrete finite volume formulation for multiprocess watershed simulation. *Water Resources Research*, 43(8), W08419. <http://dx.doi.org/10.1029/2006WR005752>

Yu, X., Duffy, C., Kaye, J., Crow, W., Bhatt, G. and Shi, Y. (2014) Watershed Reanalysis of Water and Carbon Cycle Models at a Critical Zone Observatory, in *Remote Sensing of the Terrestrial Water Cycle* (eds. V. Lakshmi, D. Alsdorf, M. Anderson, S. Biancamaria, M. Cosh, J. Entin, G. Huffman, W. Kustas, P. van Oevelen, T. Painter, J. Parajka, M. Rodell and C. Rüdiger), John Wiley & Sons, Inc, Hoboken, NJ. <http://dx.doi.org/10.1002/9781118872086.ch31>



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