JACKSON SCHOOL OF GEOSCIENCES DGS

Term Paper of Physical Climatology

Retrieval and Application of Land Surface Temperature (LST)

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WHAT STARTS HERE CHANGES THE WORLD
THE UNIVERSITY OF TEXAS AT AUSTIN

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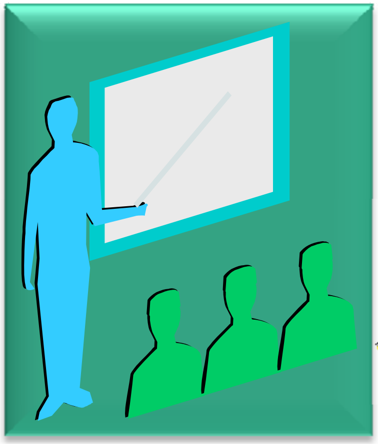
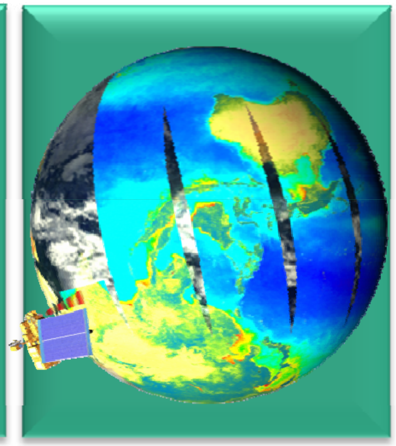
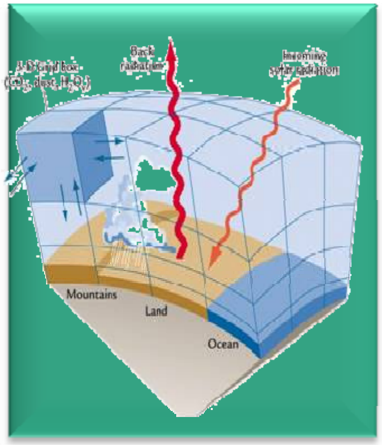


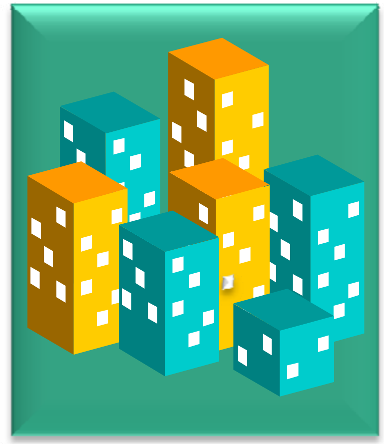
Introduction



Remote Sensing



Model



Application

Summary

Introduction

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Indicator of Climate change

control of upward terrestrial radiation

Land Surface Temperature

Hazard prediction mitigation

water management

Crop Management

Problem

Accurate LST Dataset over Global Continents

Gaps between Research and User Community

Introduction

Remote Sensing LST

Model LST

In Situ LST

Remote Sensing of LST

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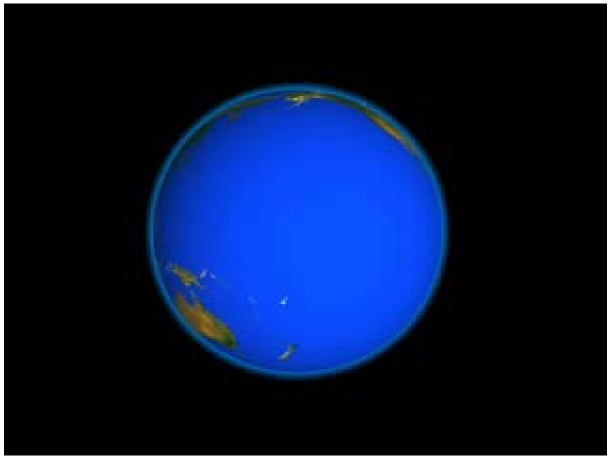
AVHRR (Advanced Very High Resolution Radiometer)		MODIS (Moderate Resolution Imaging Spectroradiometer)	
Band	Band range (µm)	Band	Band range (µm)
1	0.572-0.697 (Visible)	1	0.620-0.670
2	0.716-0.986 (Near infrared)	2	0.841-0.876
3	3.54-3.94 (Middle infrared)	20	3.660-3.840
4	10.32-11.32 (Thermal infrared)	31	10.780-11.280
5	11.41-12.38 (Thermal infrared)	32	11.770-12.270

EOS instrument
Terra AM
Aqua PM



Remote Sensing of LST

- Split Window Algorithm

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Wan, 1996

Step3 — Using Atmospheric Lower Boundary Temperature

Step2 — Using Column Water Vapor

$$T_s = C + (A_1 + A_2 \frac{1-\varepsilon}{\varepsilon} + A_3 \frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_1 + T_2}{2} + (B_1 + B_2 \frac{1-\varepsilon}{\varepsilon} + B_3 \frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_1 - T_2}{2}$$

Step1 — View-Angle Dependent LST Algorithm

Sun, 2003

Advanced split-window algorithm – for daytime LST retreival

$$T_s(k) = a_0(k) + a_1(k)T_{11} + a_2(k)T_{12} + a_3(k)(T_{11} - T_{12})^2 + a_4(k)(\sec\theta - 1)$$

The three-channel LST algorithm (for night time LST retreival)

$$T_s = a_0 + a_1 T_{i1} + a_2 T_{i2} + a_3 T_{i3} + a_4 \frac{1-\varepsilon_{i1}}{\varepsilon_{i1}} T_{i1} + a_5 \frac{1-\varepsilon_{i2}}{\varepsilon_{i2}} T_{i2} + a_5 \frac{1-\varepsilon_{i3}}{\varepsilon_{i3}} T_{i3}$$

Remote Sensing of LST

-A daily long term record of NOAA-14 AVHRR LST over Africa

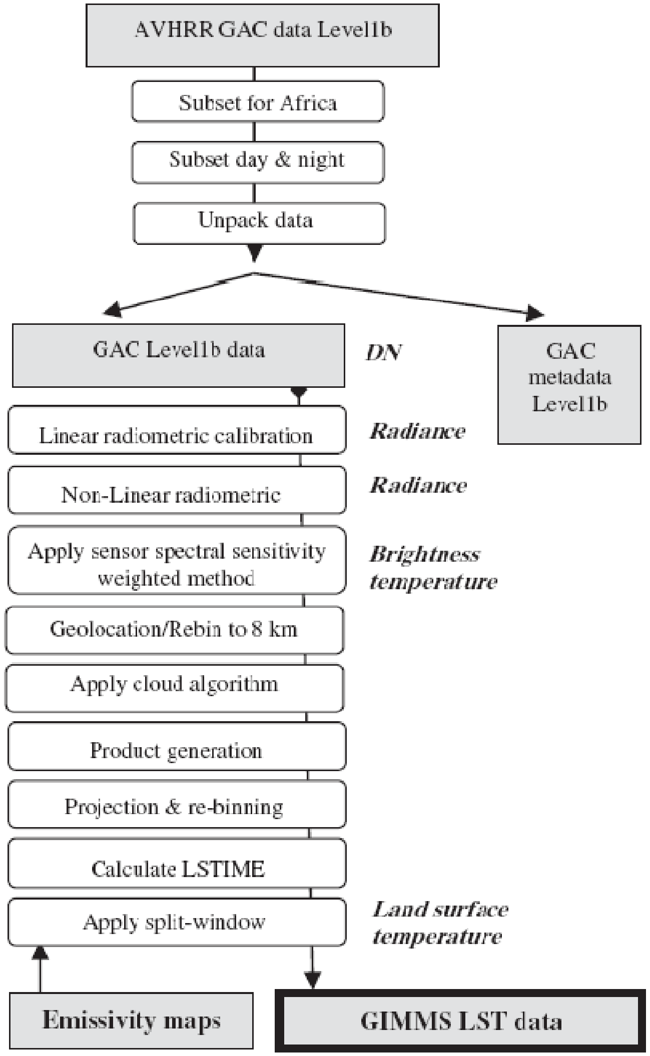


Fig.1 Schematic representation of NOAA-14 AVHRR GIMMS LST data set processing system for the thermal infrared channels

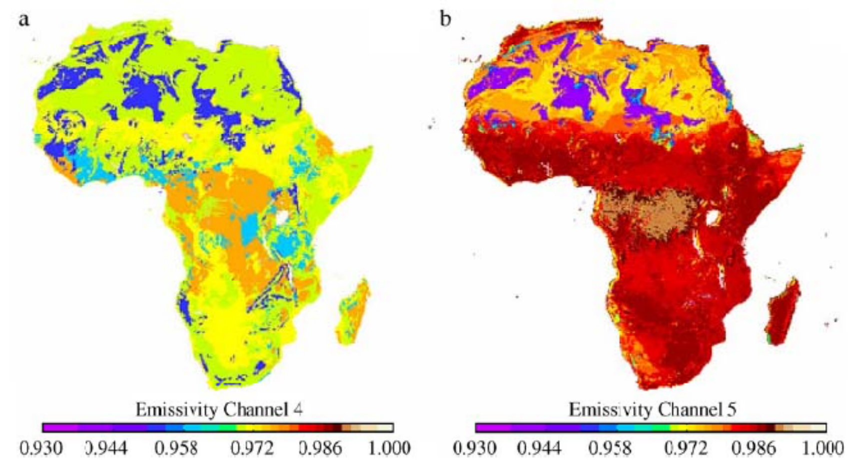


Fig.2 (a) Ensemble emissiity maps for AVHRR channel 4 and (b) channel 5

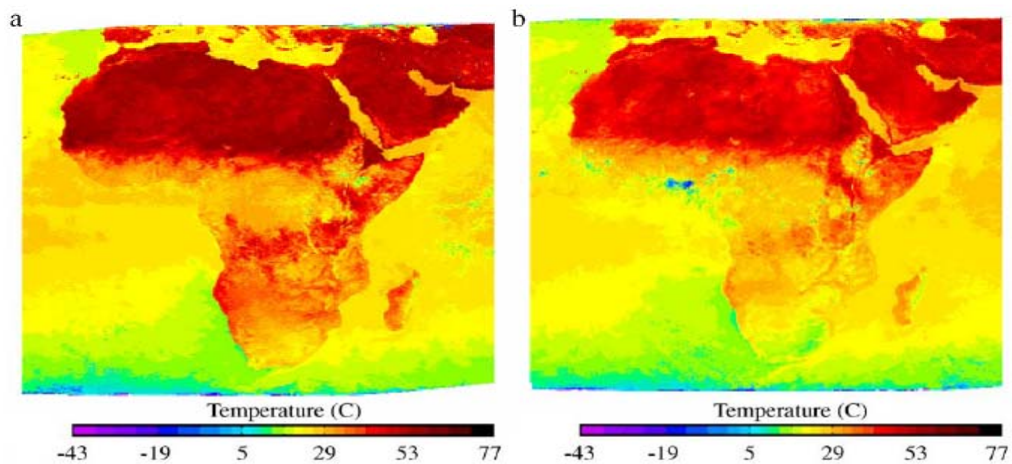


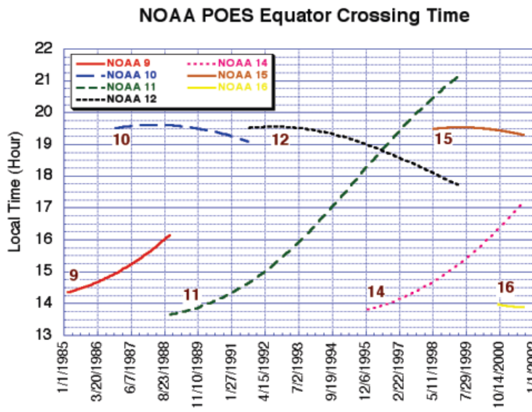
Fig.3 Composite AVHRR-derived land surface temperature for (a) July 1996 (overpass around 1:30 PM) and (b) July 2000 (overpass around 4:00 PM).

Pinheiro,2006

Remote Sensing of LST

- Analysis of Land Skin Temperature Using AVHRR Observations

- **Orbit Drift**
- **Emissivity uncertainty**
- **Cloud Contamination**
- **Lack of Diurnal Cycle**
- **View Angle**



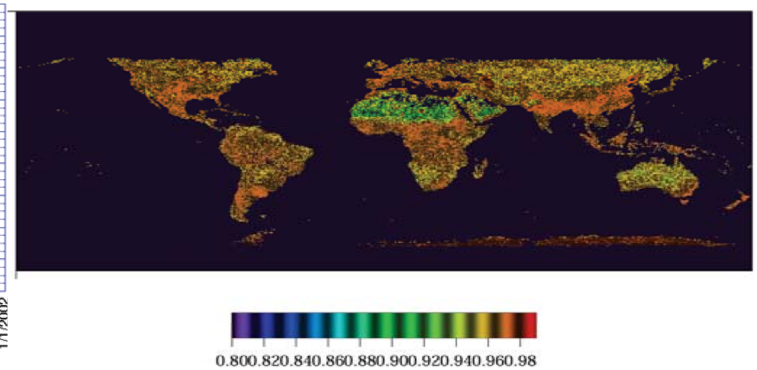


Fig.5 Global distribution of MODIS-observed land surface emissivity. It is broadband emissivity converted from MODIS spectral emissivity using MODTRAN

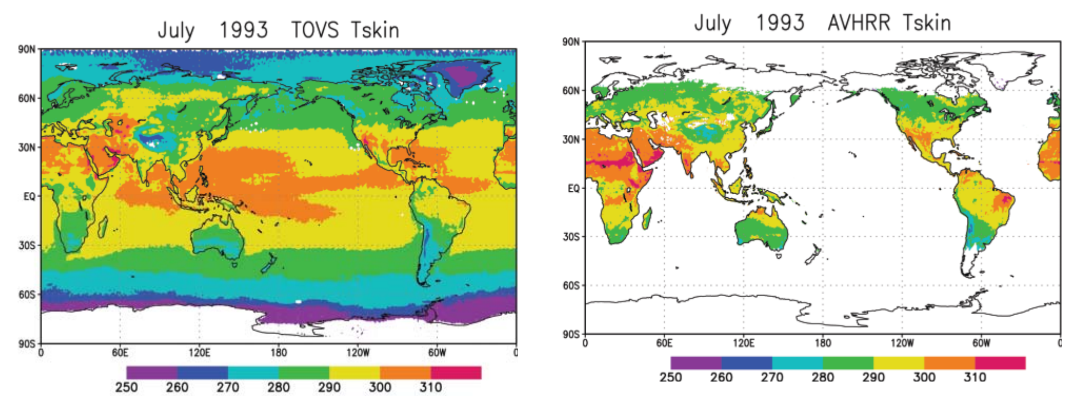


Fig.6 Comparison of (a) TOVS skin temperature with (b) AVHRR-based LSTD diurnal-averaged LST. Both AVHRR and TOVS data are the monthly mean for Jul 1993.

Jin, 2003

Modeling of LST

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LST Calculation

Global Climate Model (GCM) land surface schemes

National Centers for Environmental Prediction model (NCEP)

NCAR Land Model version 2 (CLM2)

Modeling of LST

-Improvement of Land Surface Emissivity Parameter for Land Surface Models

Relationship: Broadband Emissivity *vs.* MODIS Spectral Emissivity

$$\varepsilon_{8-14} = 0.0139\varepsilon_{29} + 0.4606\varepsilon_{31} + 0.5256\varepsilon_{32}$$

Jin, 2006

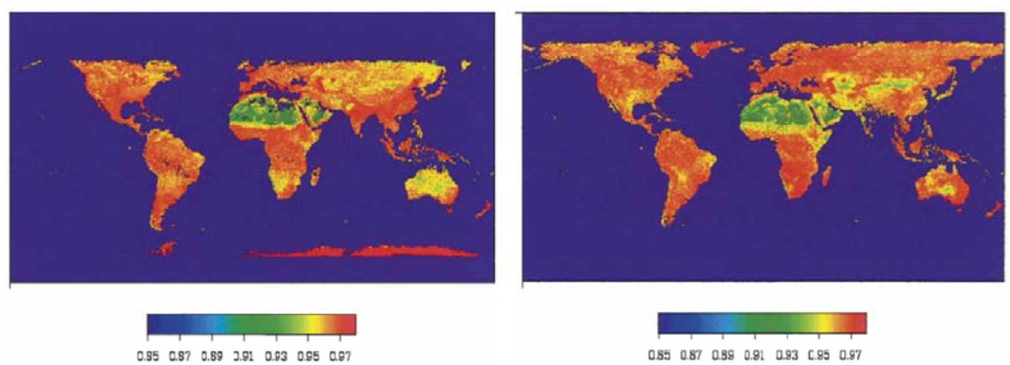

Fig. 8 (a) MODIS broadband emissivity for January 2003. The broadband emissivities are derived from the MODIS spectral band emissivities using a regression equation–based MODTRAN simulation. The resolution of original MODIS emissivity data is 1 km and here is averaged to the T42 resolution of the climate model. (b) Same as in (a), but for July 2001.

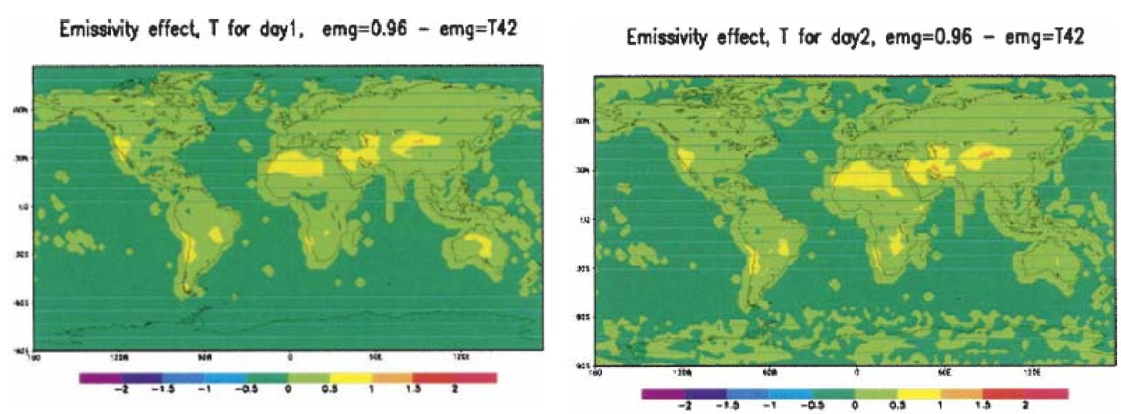

Fig.9. Coupled CAM2–CLM2 simulated emissivity impact on surface temperature (K) for two random days in September. The difference is the control run minus the sensitivity run. The control run uses CLM default soil emissivity (ε= 0.96), and sensitivity run uses satellite-observed emissivity at T42 resolution.

Modeling of LST

- Assimilation of remotely sensed LST

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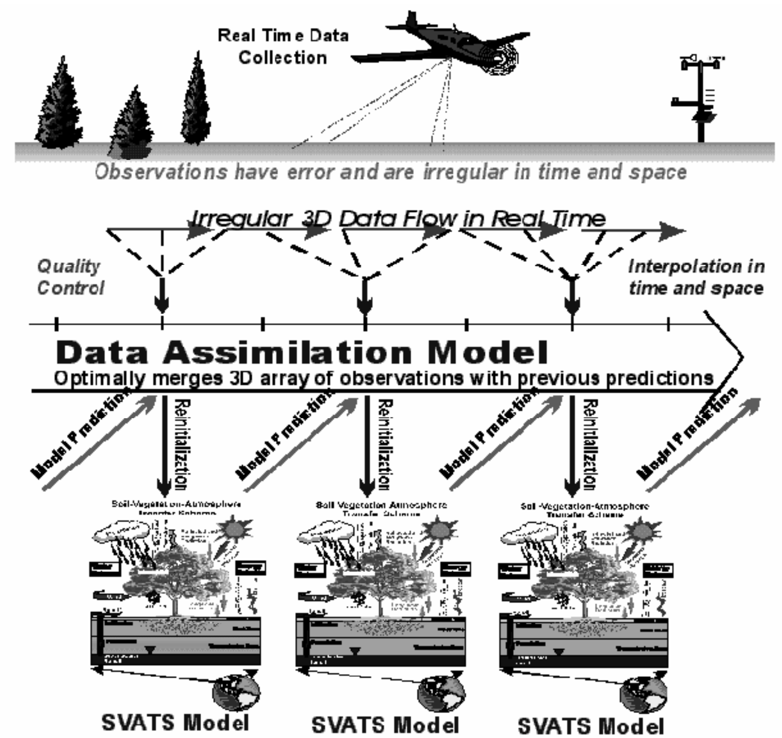

Land Surface Data Assimilation Process **Sini, 2008**

Application of LST
- LST Product Requirements

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Land Surface Temperature and Emissivity Earth System Data Record						
Subproduct	Spatial Resolution	Temporal Resolution	Accuracy	Precision	Current Data Sources	Future Data Source
Global	10-20 km	Hourly	0.5K	0.1-0.3K	AIRS GOES MSG	CrIS GOES MSG
Regional	1-5 km	2-4 times daily	0.5-1.0 K	0.1-0.3K	MODIS AVHRR ATSR	VIIRS, AVHRR ATSR
Local	30-100 m	Once every 8-16 days	0.5-1.0K	0.1-0.3K	ASTER Landsat	
Emissivity	1% or better (in 8-12.5μm) and 3% or better (in 3.6-4.2μm) all resolutions					

Workshop, 2008

Application of LST

- LST Product Requirements

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Application	Resolution (m)	Temporal Sampling	Specific Requirements
National Drought Assessment	1000	1 hr	Co-located veg cover info
Regional Drought Monitoring	50	1-7 day	Co-located veg cover info
Agriculture Yield and Water Use	50	1-7 day	Co-located veg cover info
Weather NWP	1000	1-3 hr	
Soil Moisture and Runoff	50	0.5-7 day	One obs near peak or diurnal range
Climate Science	5000	1-3 hr	Sensors overlap
Watersheds and Ecological Services	50	1-7 day	
Landuse and Urban Heat Island	50	0.5-30	Diurnal range useful
Fire	50	0.5-7 day	Height temperatures sensitivity
Lithology and Geological Hazards	50	0.5-7 day	Diurnal range useful; High temperatures sensitivity
Cryosphere	100	0.5-7 day	

Application of LST
- Challenges vs. Solutions

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Challenge

Solution

Workshop, 2008

1. Limited number of products available
2. Difficult to ascertain exactly what is available
3. No comprehensive "catalog" of all products

4. Not many are operational
5. The majority is insufficiently validated
6. Discontinuous in space and time
7. Insufficiently long term records
8. Inadequate latency
9. Spatial resolution / temporal resolution dichotomy

1. Other criteria / requirements / issues
2. LST products for all-sky conditions
3. The usefulness of LST *vs.* Tair
4. Differences between LST & Taerodynamic
5. Relationship between Tair & LST for
6. different land surface types

10. Remote Sensing products and model state variables are inherently inconstant
11. Satellite skin temperature and model surface temperature may be inherently inconsistent

Summary

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1

✓The most popular method to retrieve LST is split window algorithm.
✓However, there are too many uncertainties involved
✓Some researches constructed the LSTD to represent the diurnal variation of LST.

2

✓ GCM, NCEP, CLM2
✓ Data Assimilation System

3

There are still some challenges associated with the use of LST products for applications. In addition, some uncertainties make it impossible for the future accurate LST product.

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The end

Thank You

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Dec 2, 2008

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