Earth Surface Temperature Data Correction and Validation Processes Using MATLAB

Students

Anjeza Arapi

Karina Shah

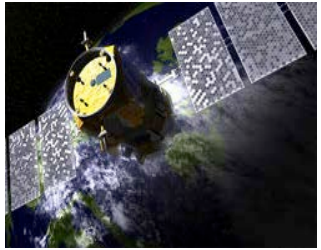
High School Teacher

Dana Hojnowski

Mentors

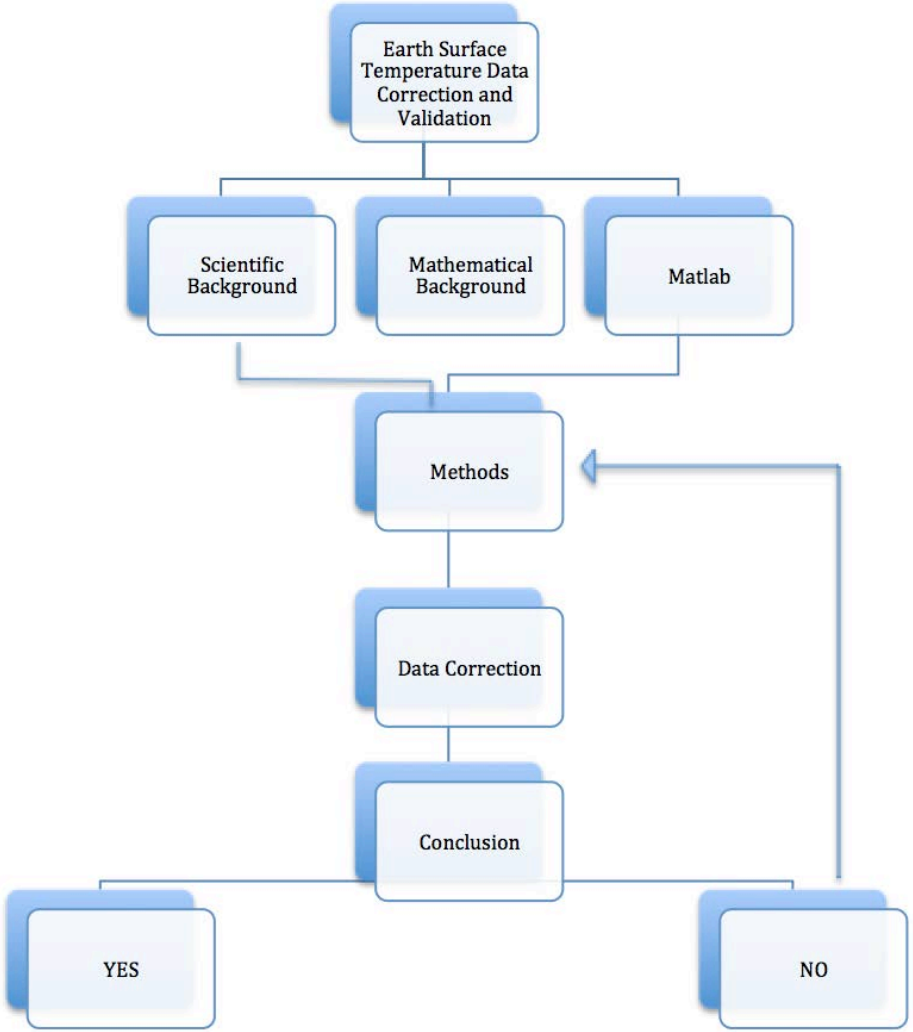
Dr. Yasser Hassebo

Dr. Reginald Eze



http://www.nasa.gov/mission_pages/calipso/multimedia/cloud_calip_mm.html

http://thisplacein.space/2015/04/12/saturday-april-11th-learning-matlab-and-arduino/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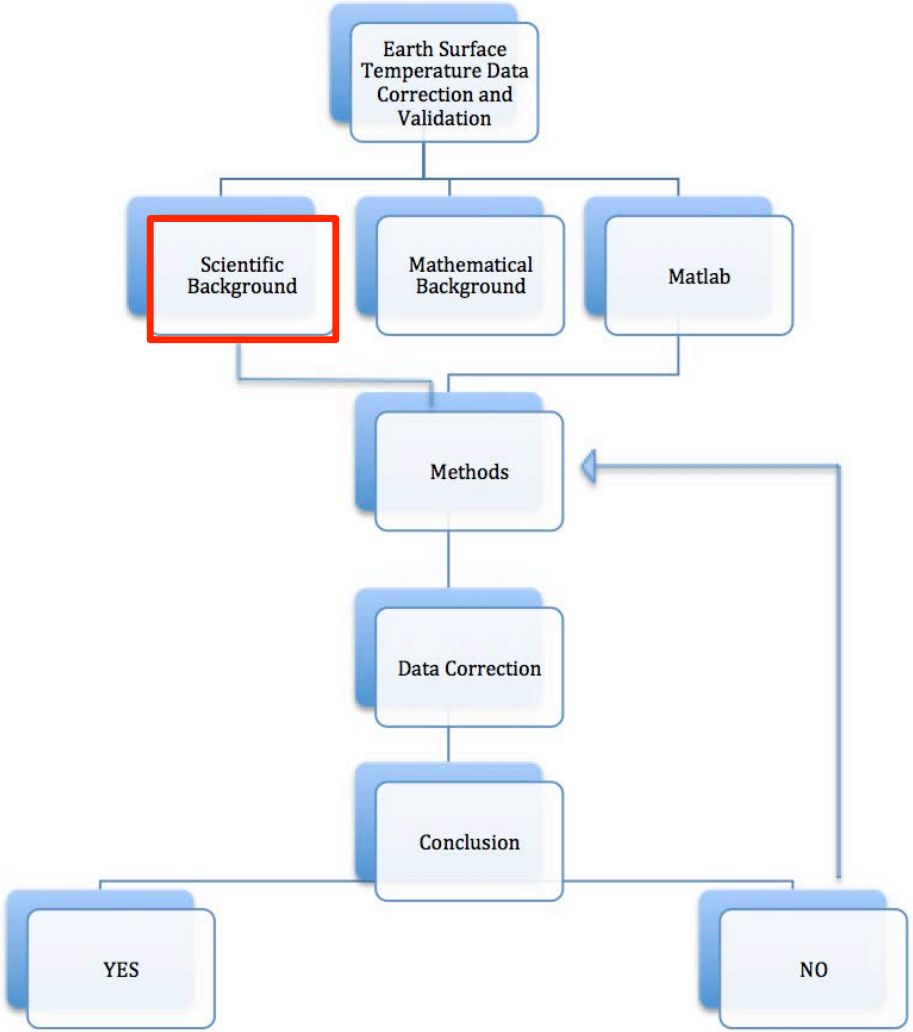
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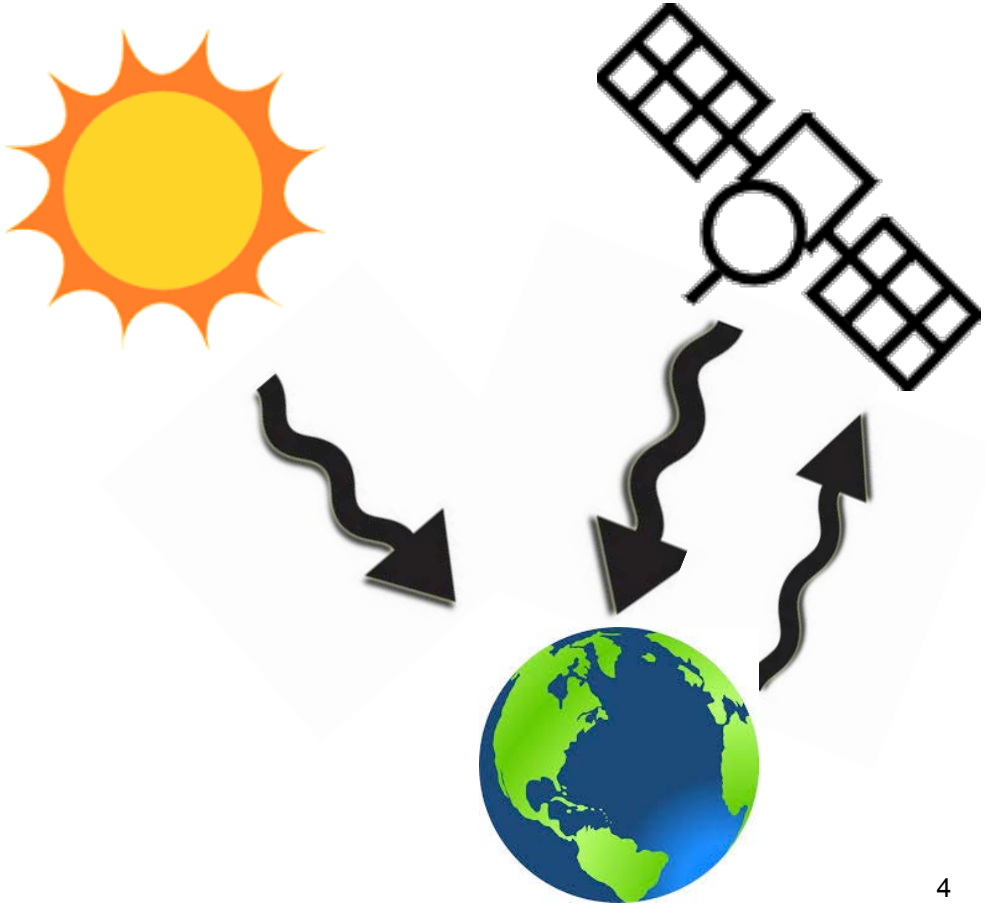
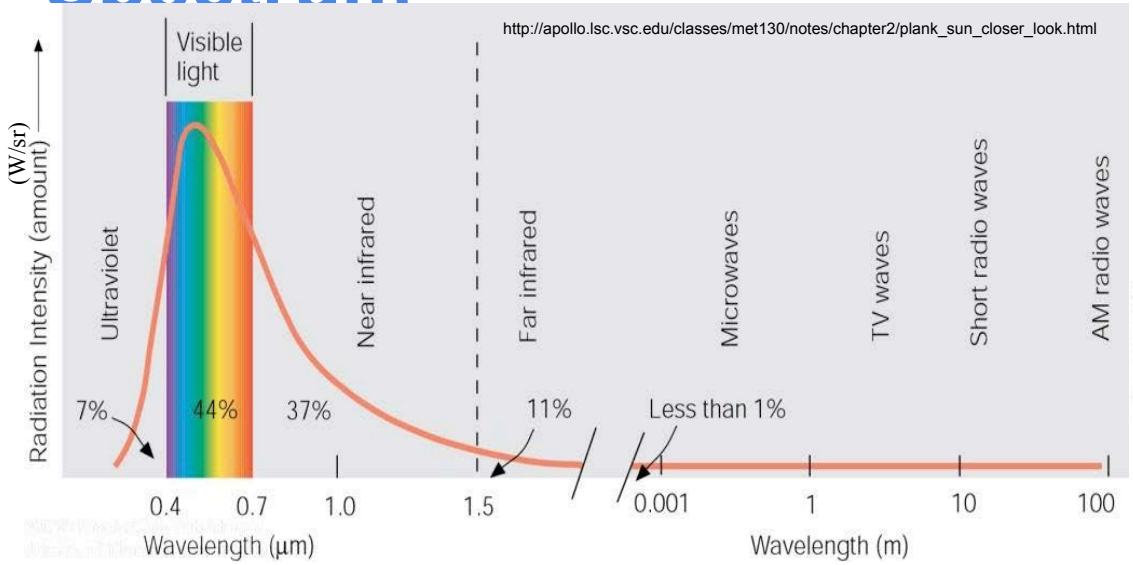
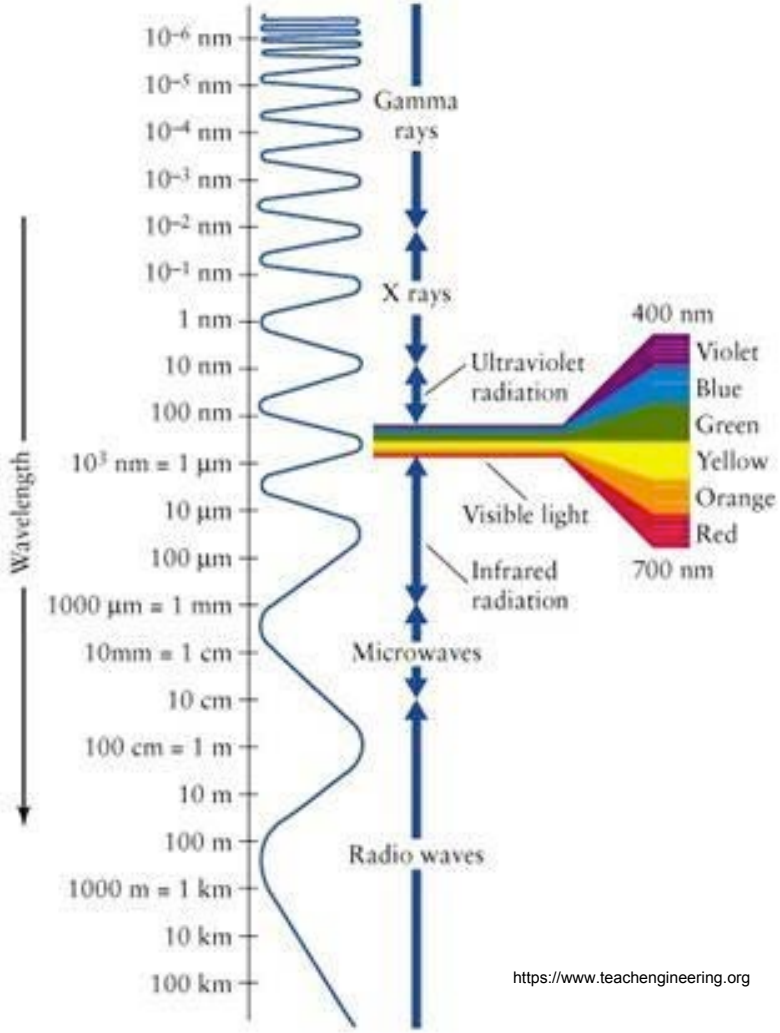
Scientific Background

- Energy from the Sun
- Infrared Radiation from Earth
- Remote Sensing Basics



Electromagnetic Spectrum





Stefan-Boltzman Law

$$q = \sigma T^4 A$$

$$\sigma = 5.6703\ 10^{-8}\ (W/m^2K^4)$$

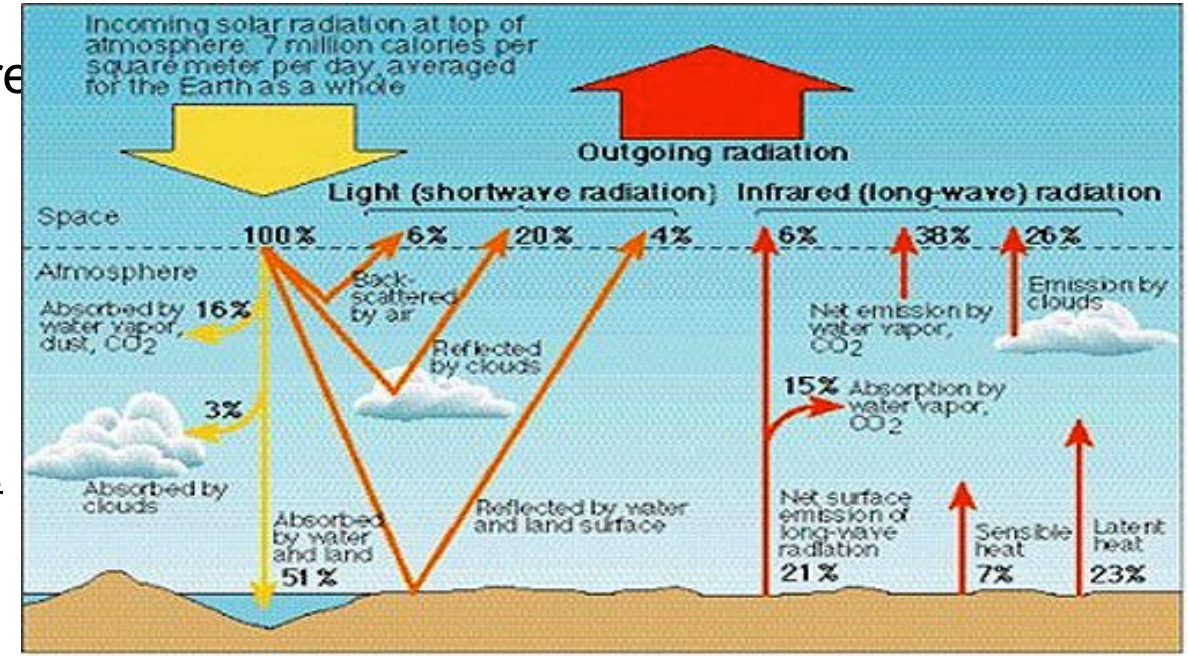
Light from the Sun

- Detect and respond to input from the physical environment

- ~20% sun → atmosphere
  ~50% sun → absorbed into Earth's surface
  ~30% sun → reflected

- The sun's energy is:

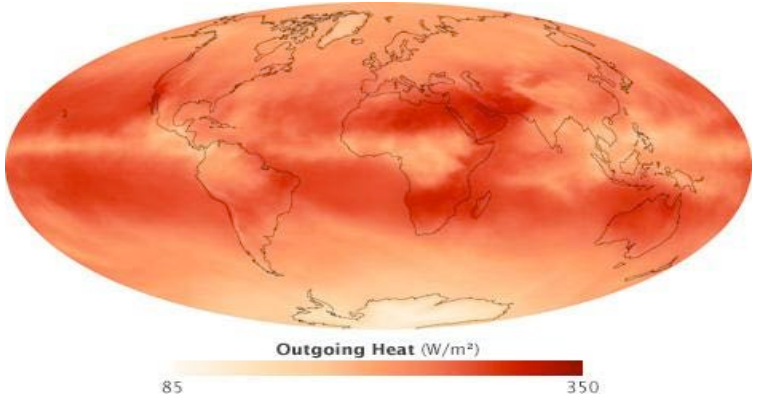
1. Reflected as <u>visible light</u>
2. Absorbed, re-emitted as <u>infrared light</u>



https://hwsclimatology.wordpress.com/2009/04/23/earths-energy-budget/

Infrared Radiation From Earth

http://earthobservatory.nasa.gov/Features/EnergyBalance/page4.php



HOTTEST 70.7 °C (159.3 °F) Lut Desert, Iran 2005	343.9K	8.42 μm (far infrared)
COLDEST -93.2 °C (−136 °F) Vostok Station, Antarctica 2006	179.8K	16.12 μm (far infrared)

WIEN'S DISPLACEMENT LAW

$$\lambda_{max} = \frac{b}{T}$$

b → [constant] 2898 μm K
T → temperature of object, K

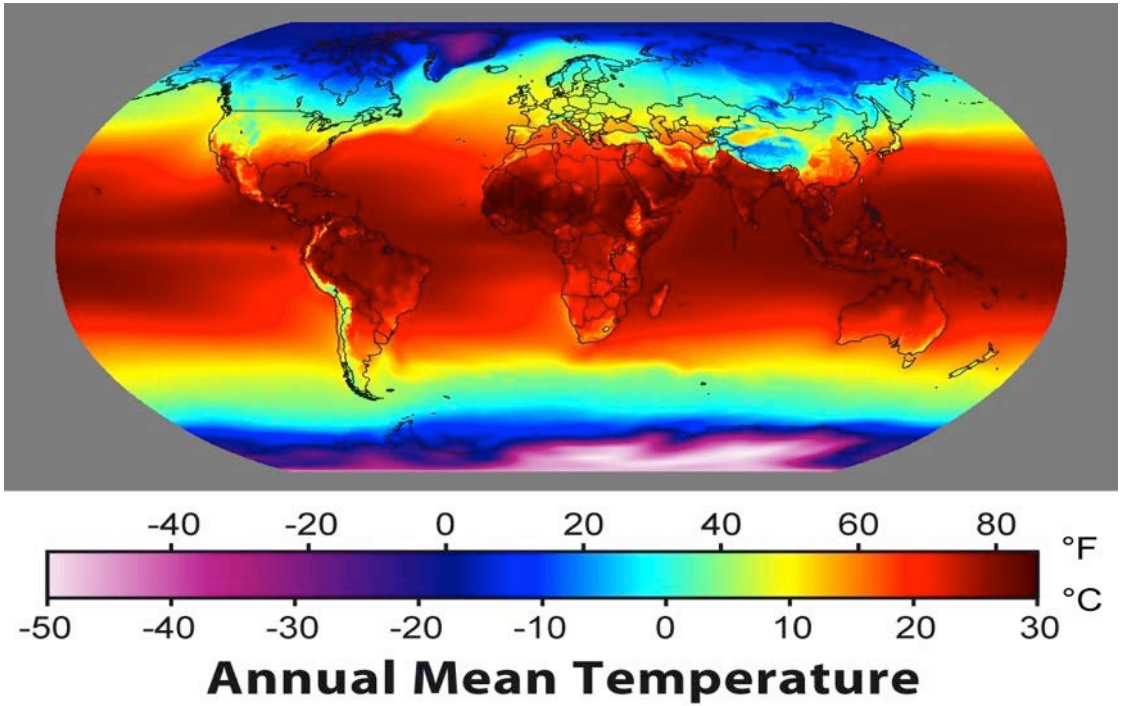
https://en.wikipedia.org/wiki/Thermal_radiation

Average Thermal Infrared Radiation Distribution

Average Temperature
July 2002, 2003, 2004, 2005:

287.68 K
= 58.14°F
= 14.52°C
(far infrared)

http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt



http://cnx.org/contents/1741effd-9cda-4 b2b-a91e-003e6f587263@43.5:15/Sustainability:_A_Comprehensiv

Thermal Infrared Remote Sensing

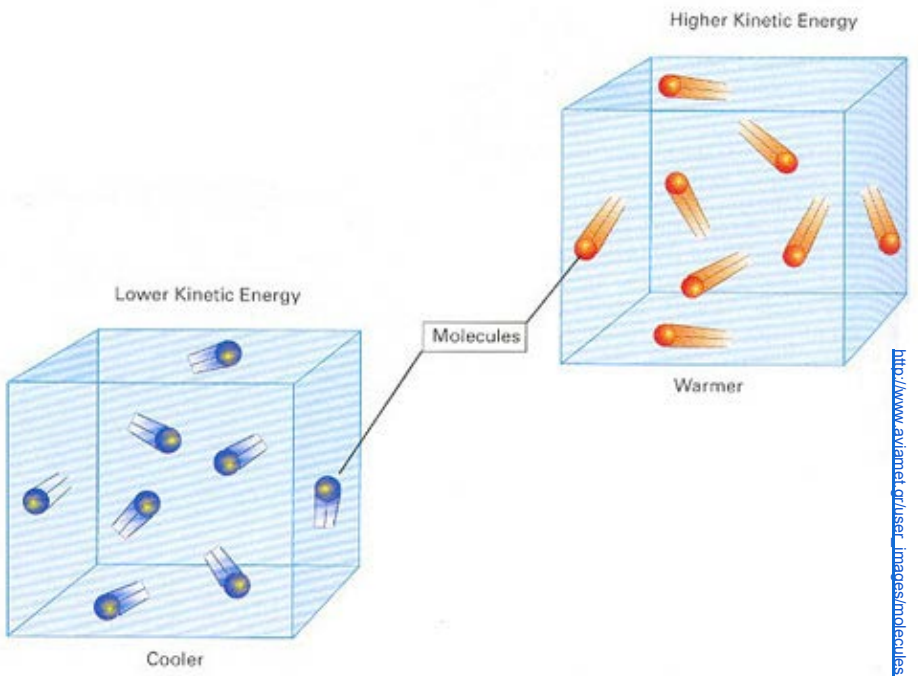
kinetic
heat

kinetic temperature

radiant flux ⇔ kinetic temperature

remote
sensin

kinetic temperature



http://www.aviamet.gr/user_images/molecules1.jpg

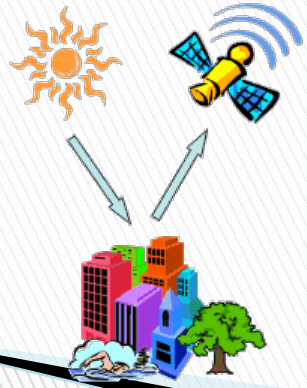
Remote Sensing

1. **Passive Remote Sensing**
   (natural energy source)
   ex. sun or thermal

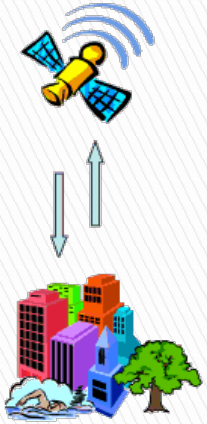
   ASTER
   LANDSAT
   MODIS

2. **Active Remote Sensing**
   (artificial energy source)
   ex. laser light or radiowaves

   LIDAR
   RADAR
   SODAR (SONAR)



Passive sensing
(using sunlight)



Active sensing

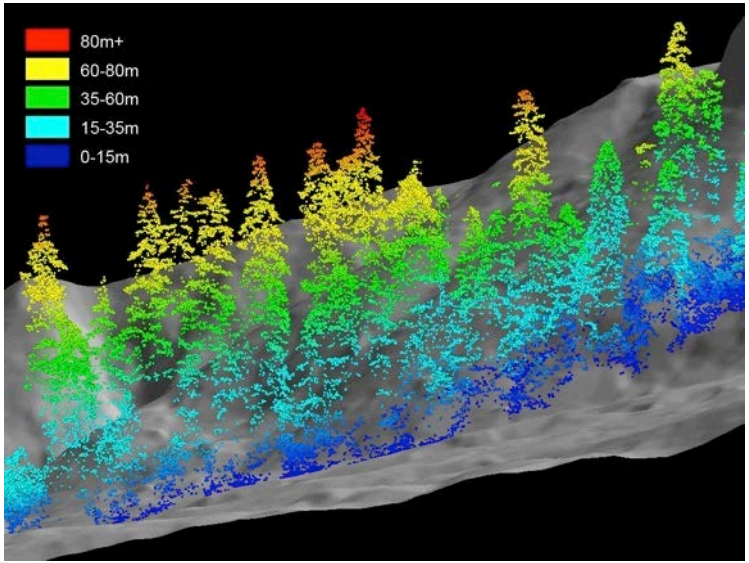
http://www.treasure-hunt.alaska.edu/ch3/info_sensing.htm

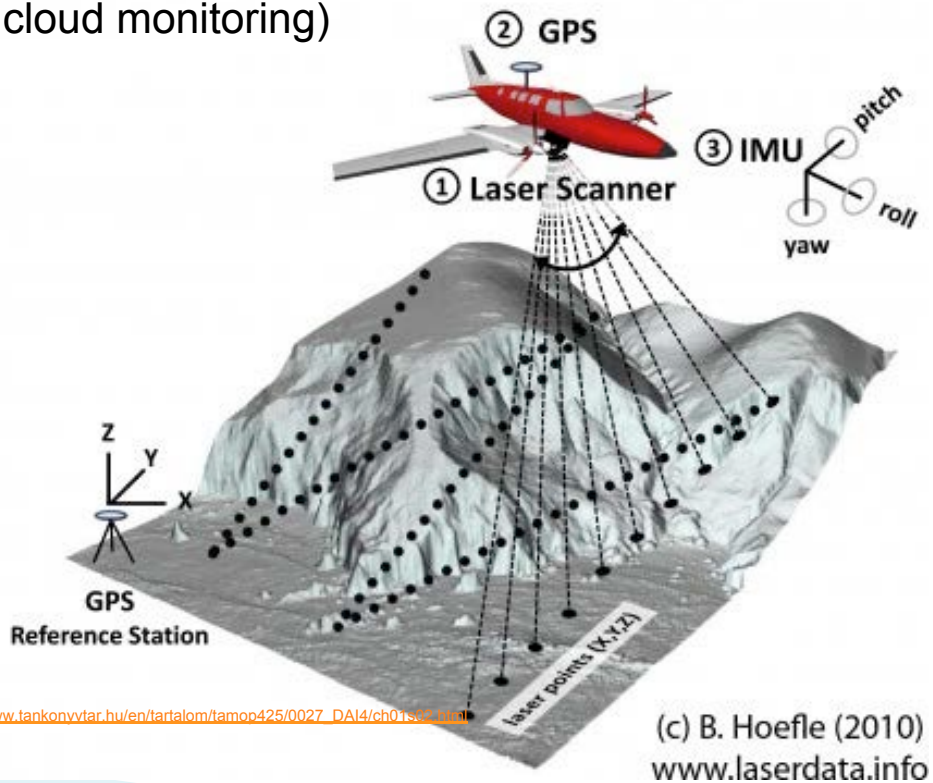
LIDAR (Active Sensing)

LIDAR: **Li**ght **D**etection **a**nd **R**anging

<u>Most Common Uses:</u>

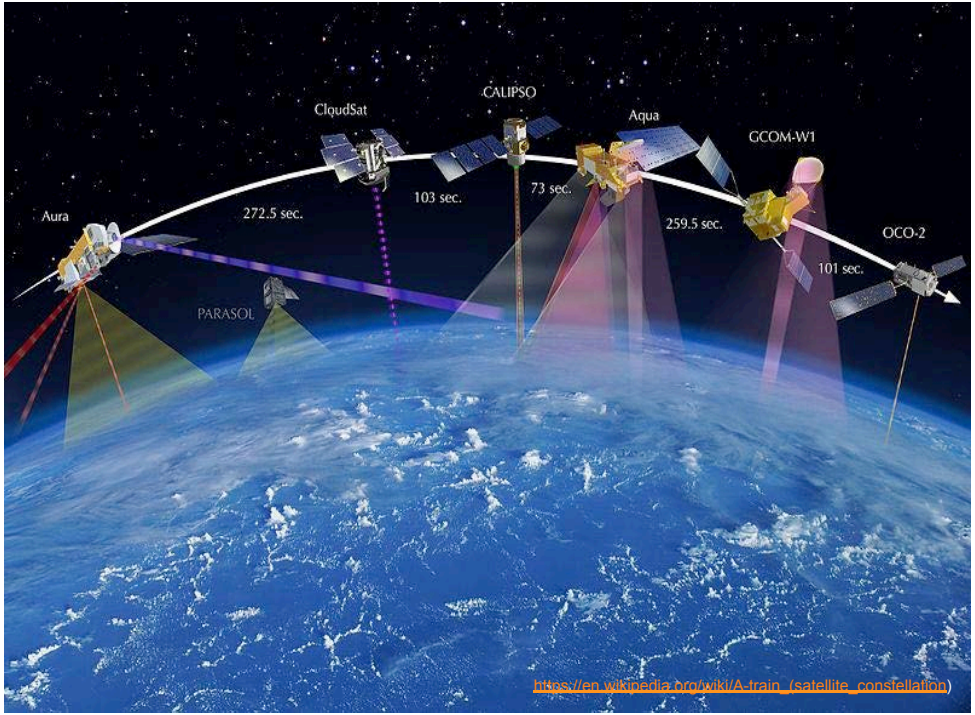
- elevation of terrain, vegetation, & seabeds
- properties of the atmosphere (aerosol & cloud monitoring)





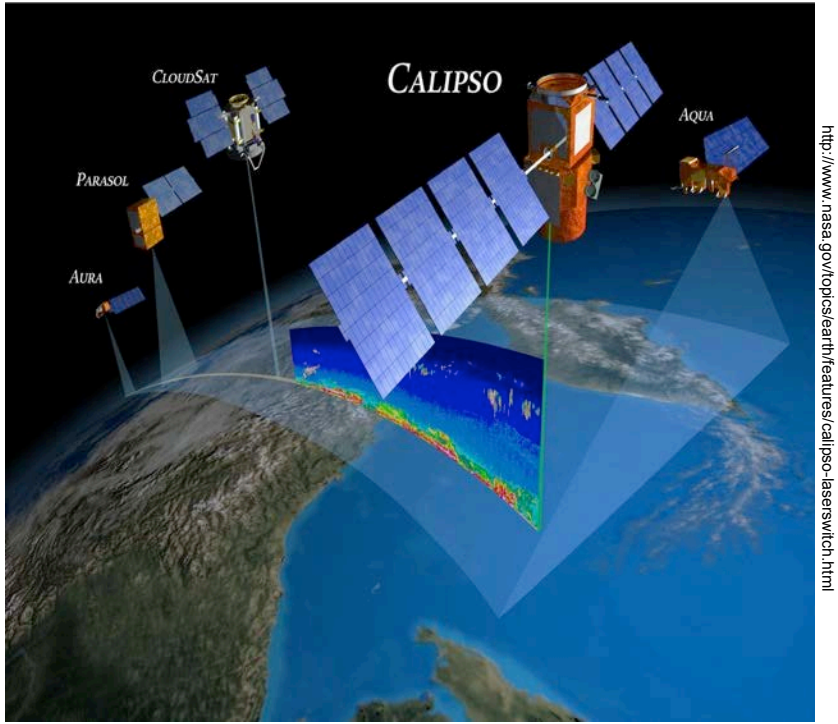
http://oregonstate.edu/terra/2010/10/light-on-leaves/http://www.tankonyvtar.hu/en/tartalom/tamop425/0027_DAI4/ch01s06.html

NASA’s A-Train



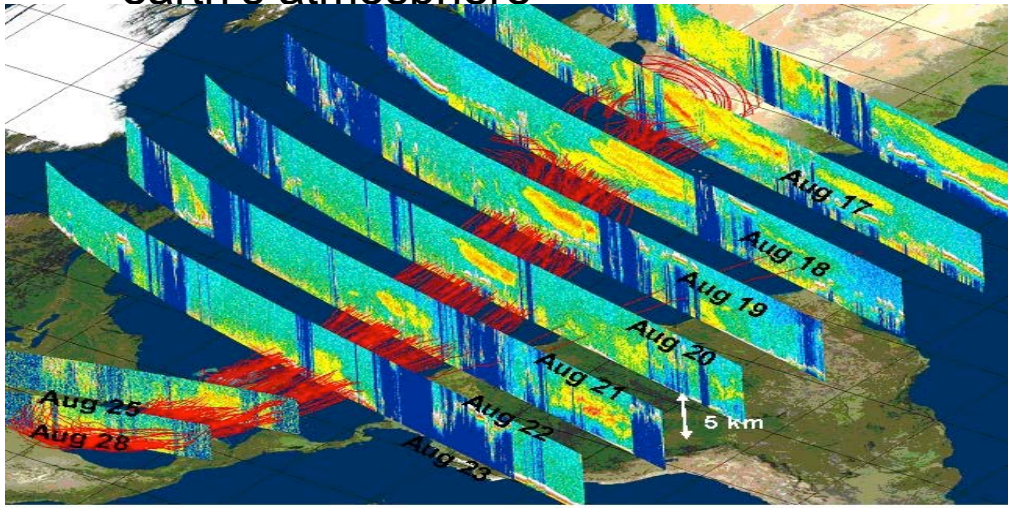
- 6 SATELLITES :
  - Aqua, CALIPSO, CloudSat, Aura, OCO-2, GCOM-W1
- follows one another on an orbital track
- crosses equator at 1:30 PM & 1:30 AM
- PROS:
  - simultaneous observation

CALIPSO



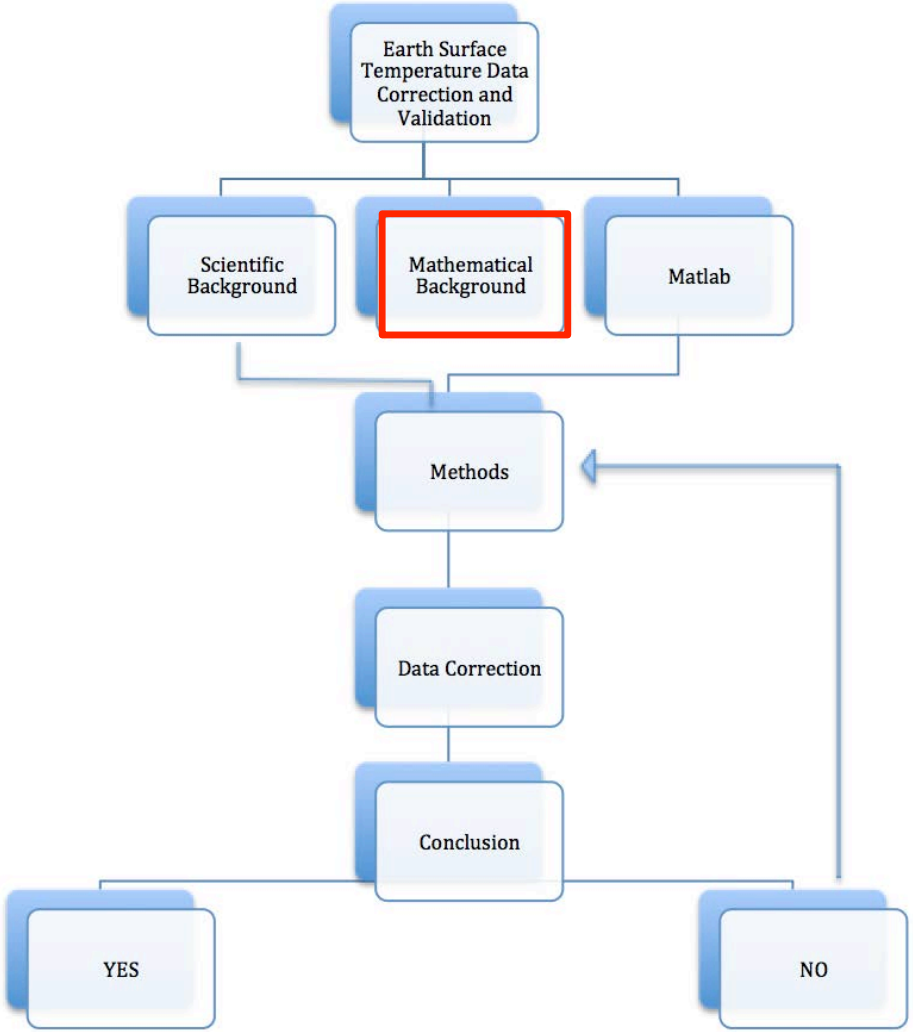
http://www.nasa.gov/topics/earth/features/calipso-laserswitch.html

- utilizes active (LIDAR) AND passive imaging
- mainly monitors aerosols and clouds in earth's atmosphere



https://cnes.fr/en/web/CNES-en/5950-french-calipso-principal-investigator-wins-nasa-award.php

http://www.lexellaser.com/techinfo_wavelengths.htm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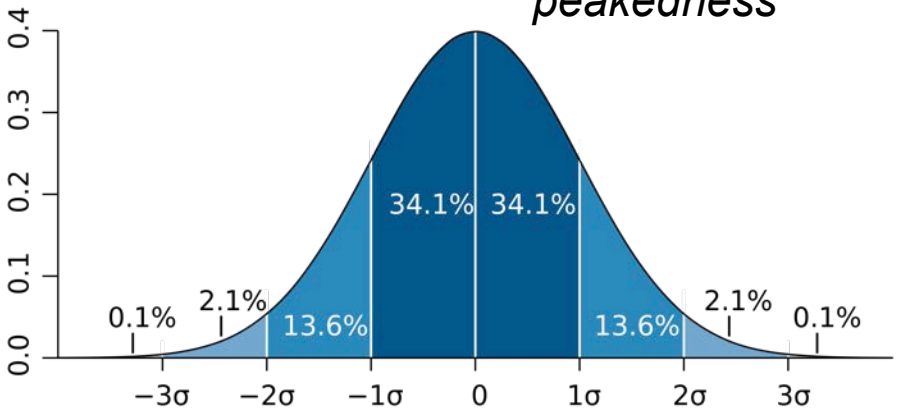
Mathematical Background: Statistics

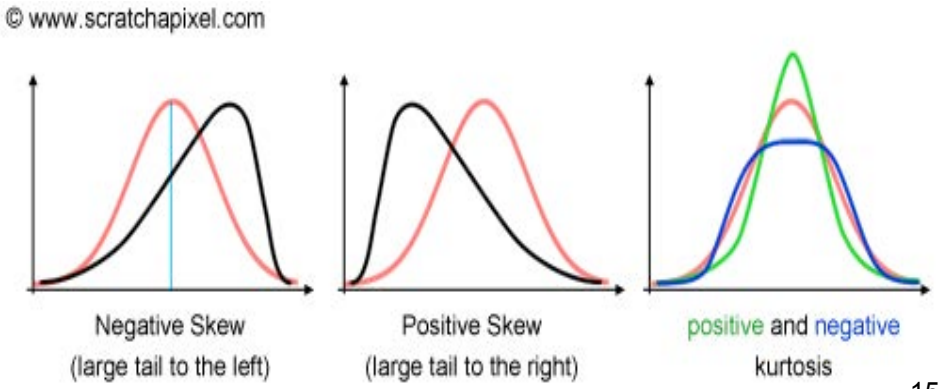
- mean *the average value of the set*
- standard deviation *deviation from the mean*
- skewness *asymmetricality*
- *peakedness*

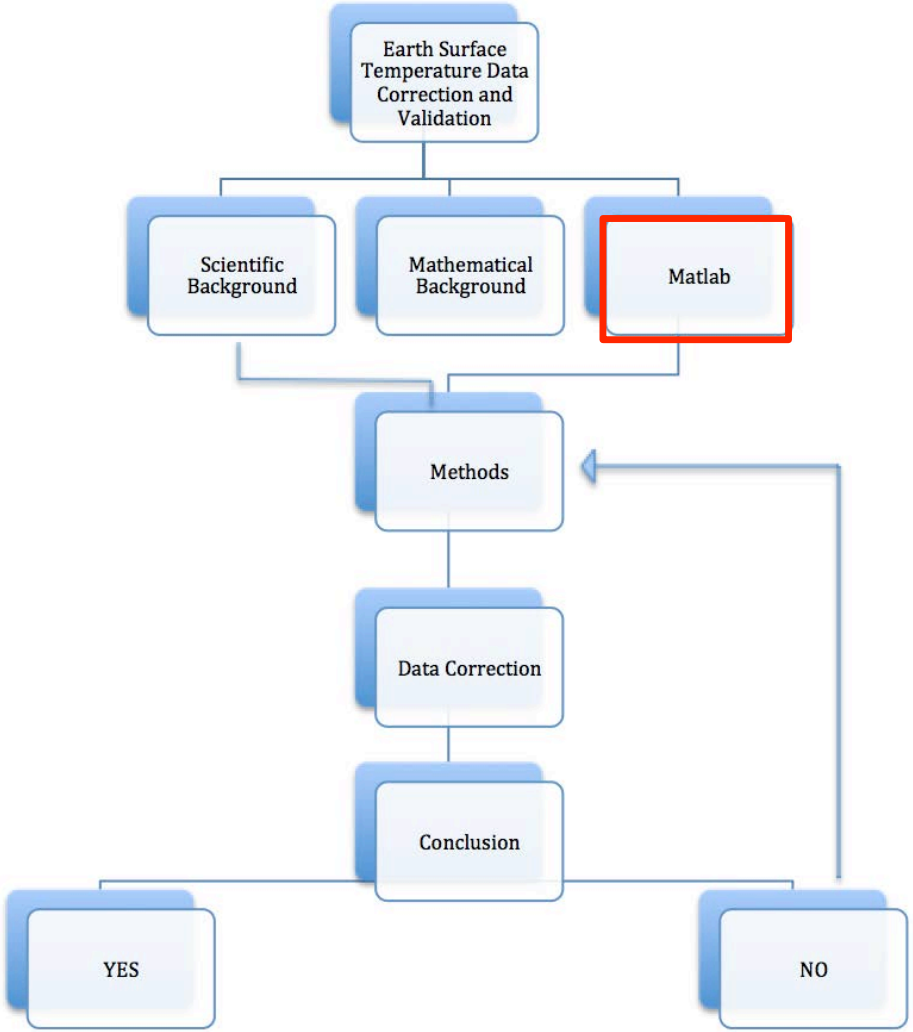
MEAN AND STANDARD DEVIATION



https://en.wikipedia.org/wiki/Standard_deviation

SKEWNESS AND KURTOSIS

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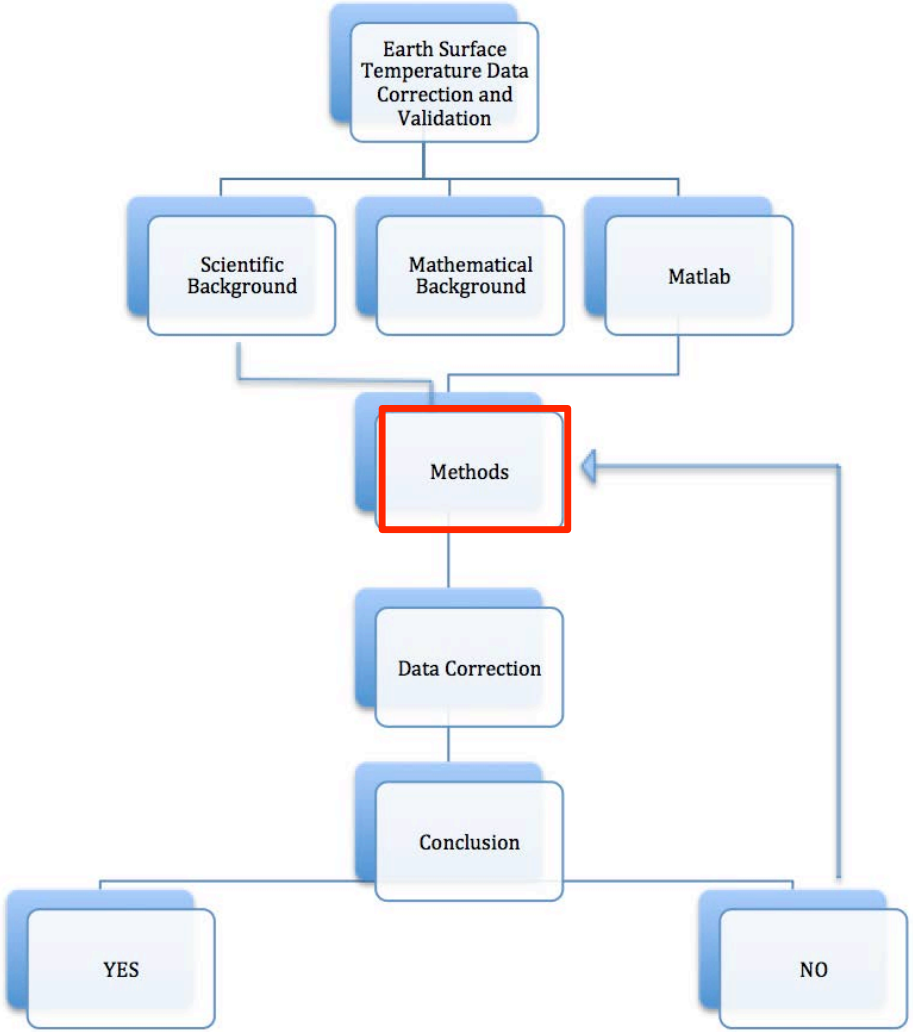
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The Validation Process

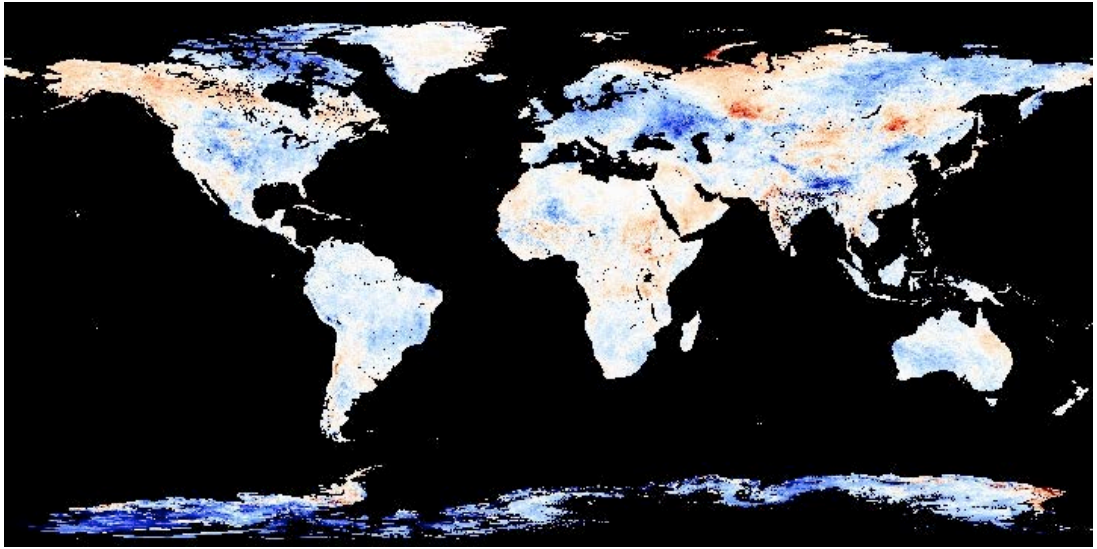
1. Find and count the **negative** data points.
   Analyze the raw data.
1. Replace these points with **zeros**.
   Re-analyze the new matrix.
1. Convert the zeros to **NaNs**.
   Re-analyze this new matrix.
1. Interpolate data taking average of **horizontal** non-negative values.
   Re-analyze this new matrix.
1. Interpolate data taking average of **linear** values (both horizontal and vertical).
   Re-analyze this new matrix.

Negative Data Points

ANOMALIES ON THE SURFACE

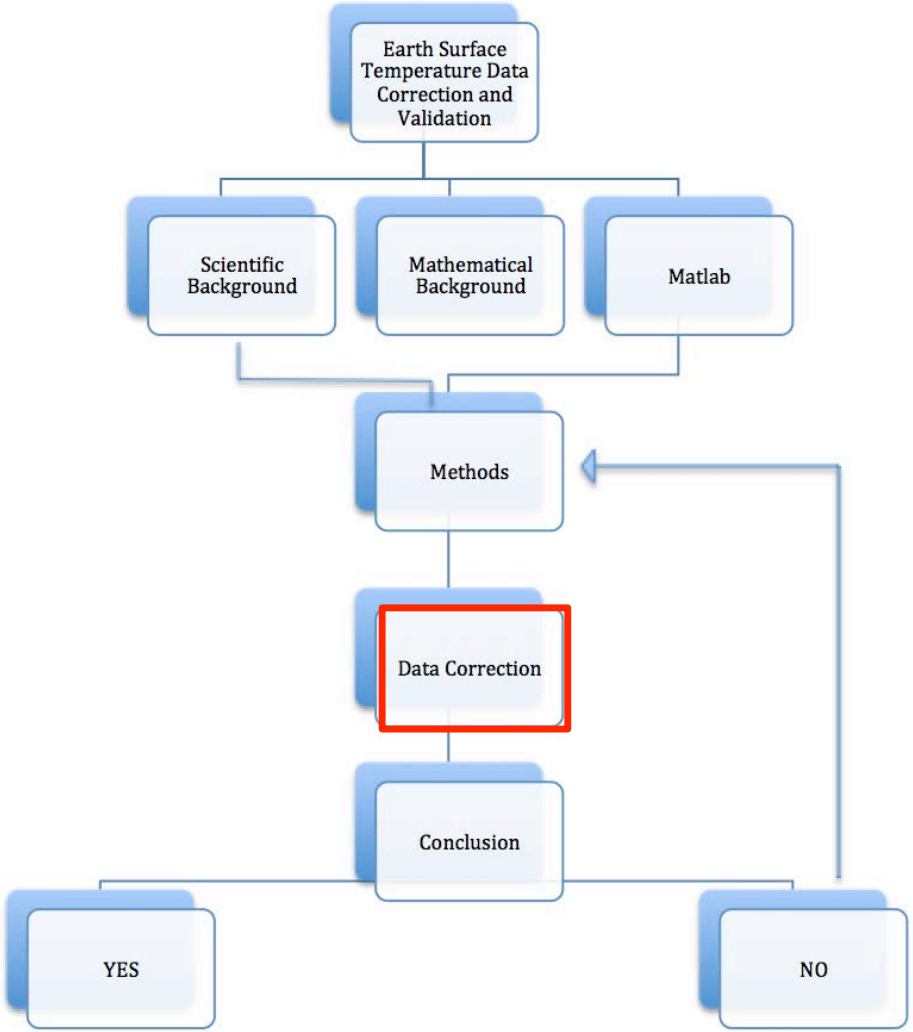
- **WARMER** than average --
  - high precipitation event
  - low sea ice extent
  - volcanic eruptions
  - wildfires

- **COOLER** than average--
  - high precipitation events
  - winter storms
  - drought



http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MOD_LSTAD_M&year=2004

July 2004 Anomalies from NASA Earth Observations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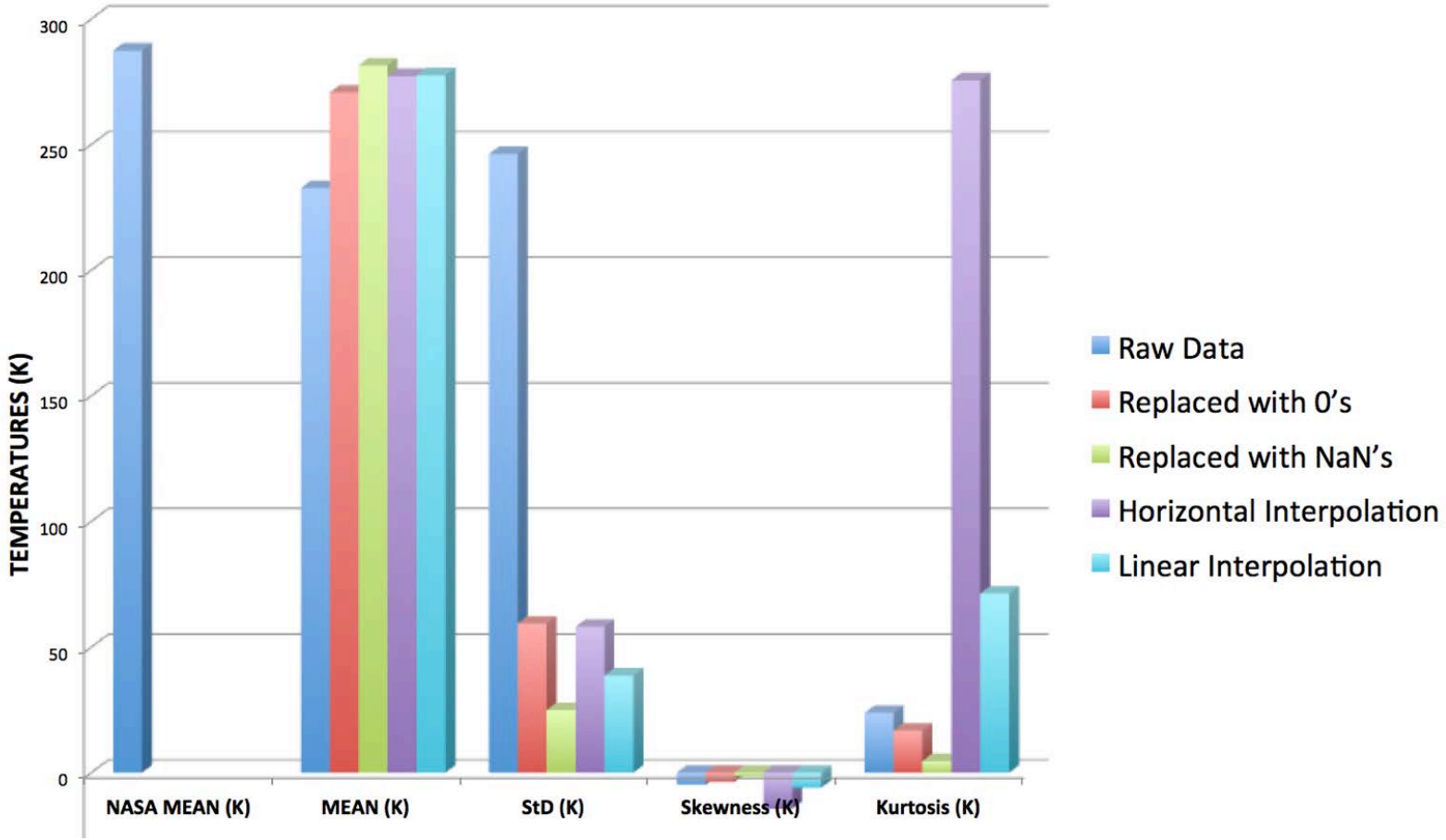
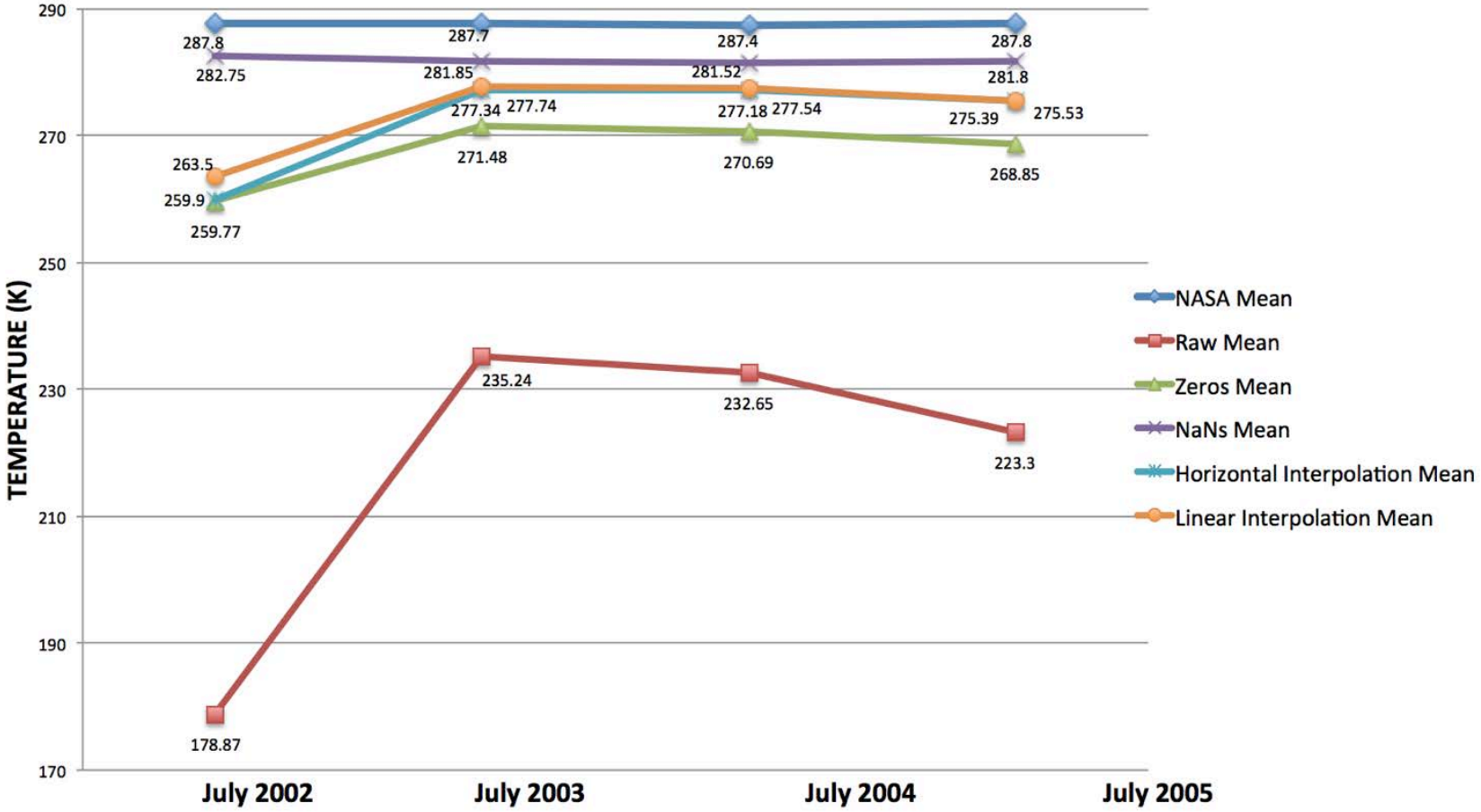
Results: July, 2004

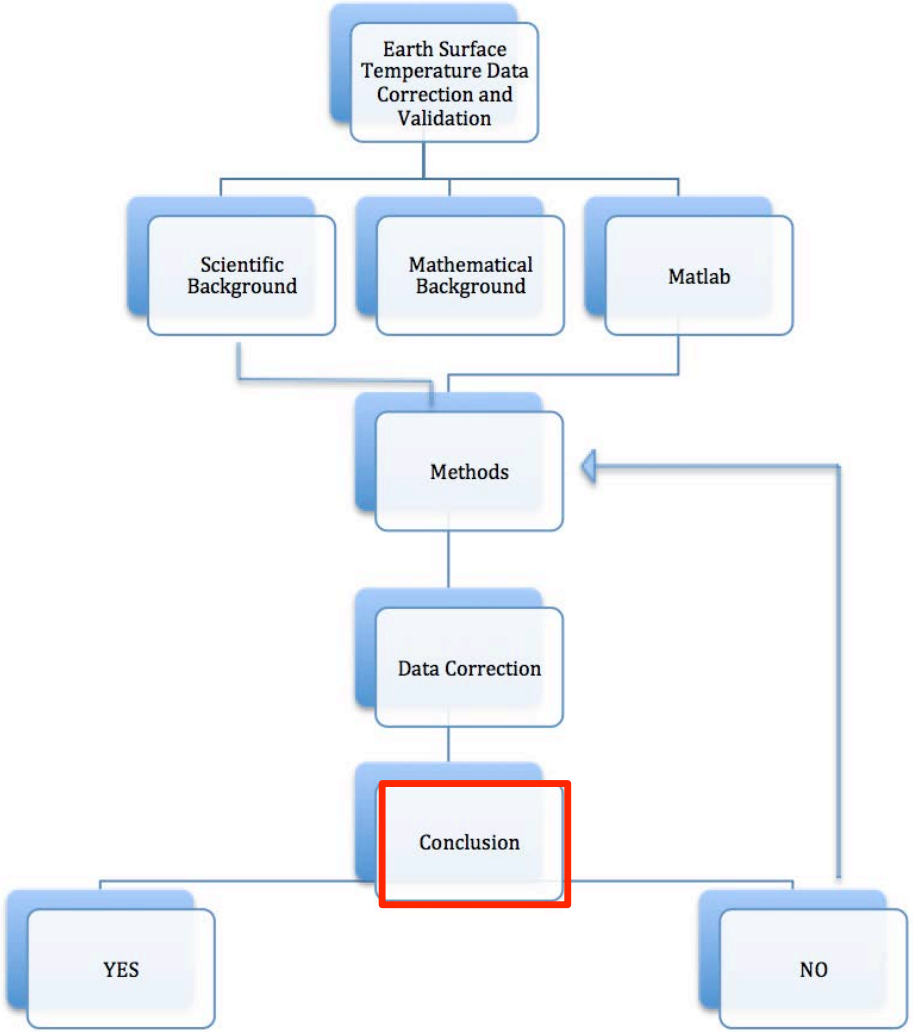
	Raw Data	Raw Data	Raw Data	Raw Data	Raw Data
Raw Data	287.4 57.69 14.27	232.65 -40.90 -40.50	246.24 -16.45 -26.91	-4.75 -468.22 -277.90	23.83 -416.77 -249.32
Replaced with 0's	287.4 57.69 14.27	270.69 27.57 -2.46	59.39 -352.76 -213.76	-3.64 -466.22 -276.79	16.71 -429.60 -256.44
Replaced with NaN's	287.4 57.69 14.27	281.52 47.07 8.37	24.88 -414.89 -248.27	-1.35 -462.11 -274.50	4.65 -451.29 -268.50
Horizontal Interpolation	287.4 57.69 14.27	277.18 39.26 4.03	58.09 -355.10 -215.06	-14.28 -485.28 -287.37	275.57 36.36 2.43
Linear Interpolation	287.4 57.69 14.27	277.54 39.90 4.39	38.68 -390.04 -234.46	-6.00 -470.48 -279.15	71.31 -331.31 201.84

Statistical Analysis: July, 2004



2002-2005 Earth Surface Temperature (K)

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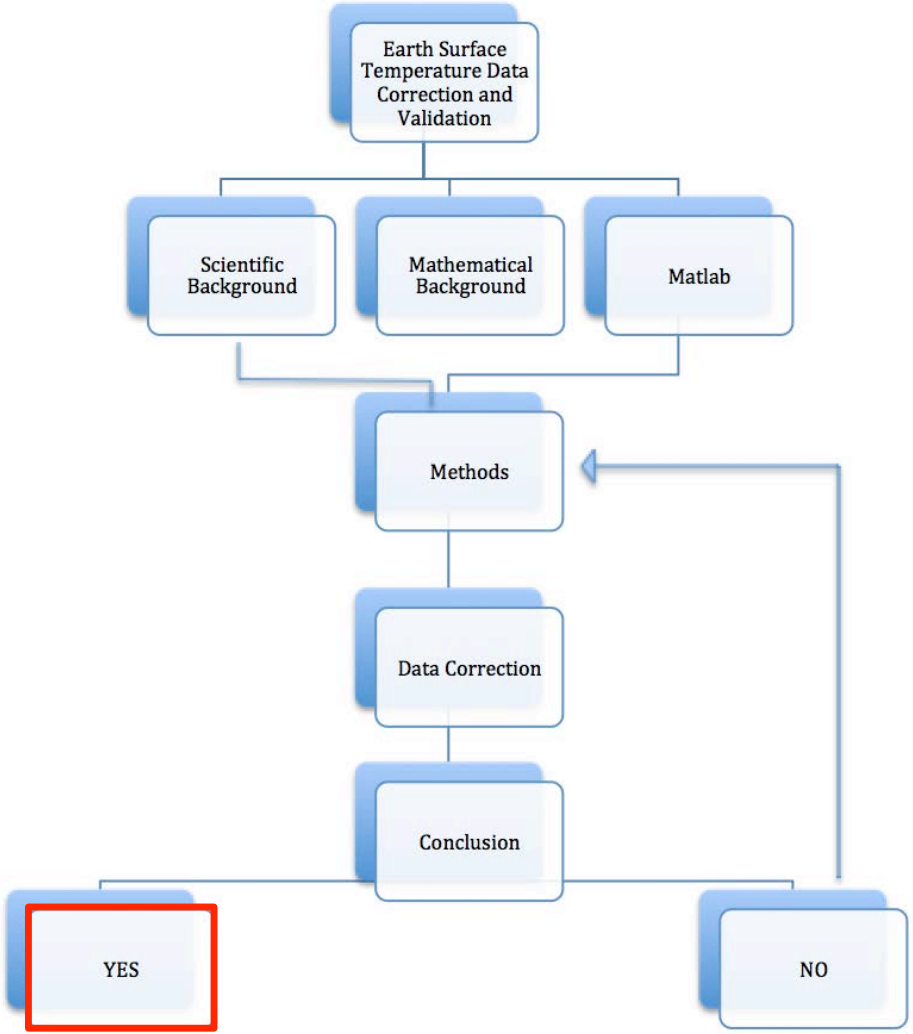
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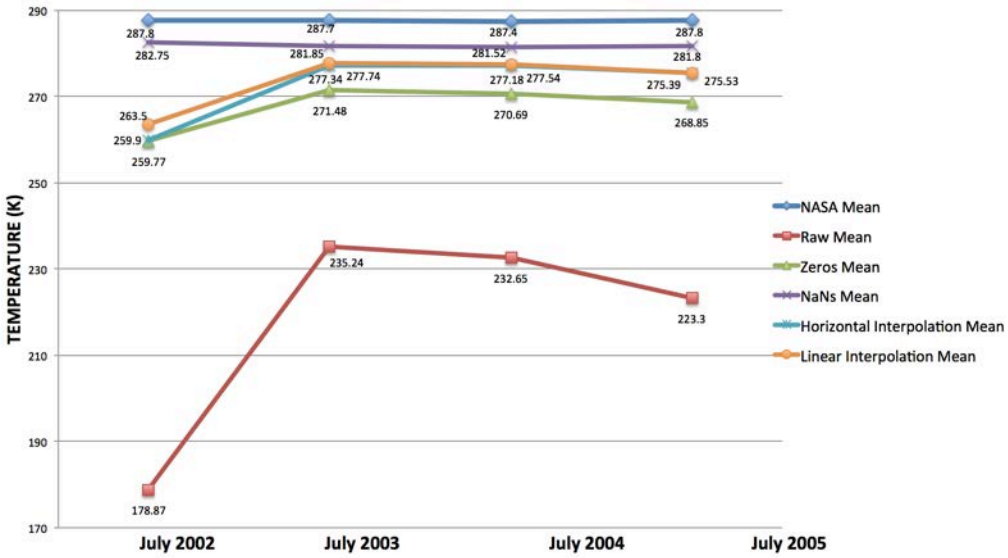
“YES, our data has been largely validated and corrected, so we can CONCLUDE ...”

- further interpolation to take into account weighted global grid areas

- the validated data is in flux from July 2002 - July 2005, which is not enough evidence to support global warming

2002-2005 Earth Surface Temperature (K)



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