Eratosthenes - chasing shadows to investigate glacier change worldwide

Bas Altena, Bert Wouters, Michiel van den Broeke, A. Kääb, B. Raup, T. Scambos, T. Harrison & S. Saunier

Utrecht University, eScience center, University of Oslo, National Snow and Ice datacenter, University of Colorado, Planet & Telespazio

Eratosthenes in a nutshell

a project that,

processes the **historical** satellite archive ...
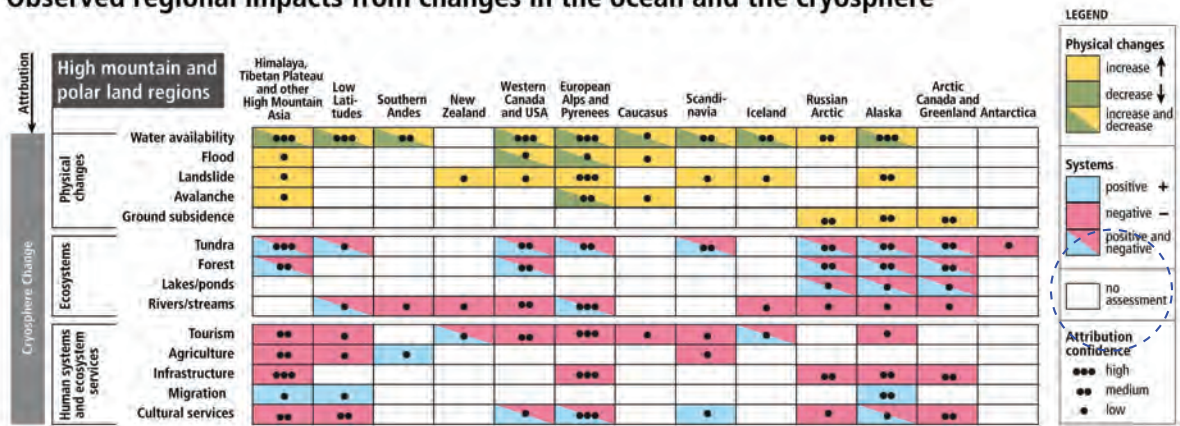
with **ancient** techniques ...

but with **modern day** processing power

aim: **surface elevations from shadows**

Research of the Cryosphere   ("cryo" is Greek for "cold")

Observed regional impacts from changes in the ocean and the cryosphere
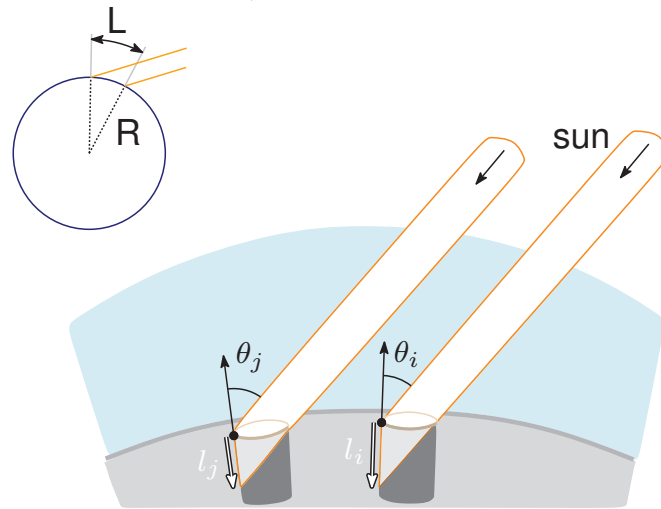

from the newest IPCC special report on Oceans and Cryosphere, chapter 2.

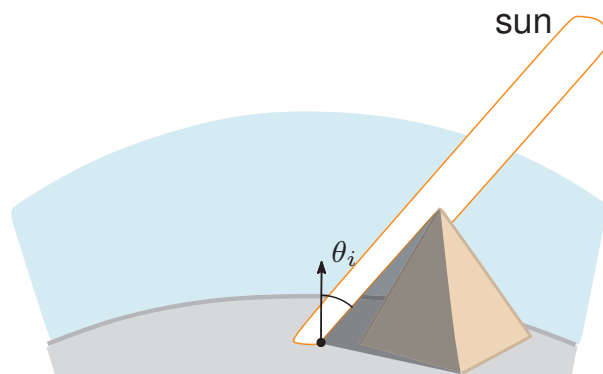## Aristotle (384 - 322 BC) : proof of Earth's round shape

crescent shape of cast shadow on the Moon, observable during a lunar eclipse
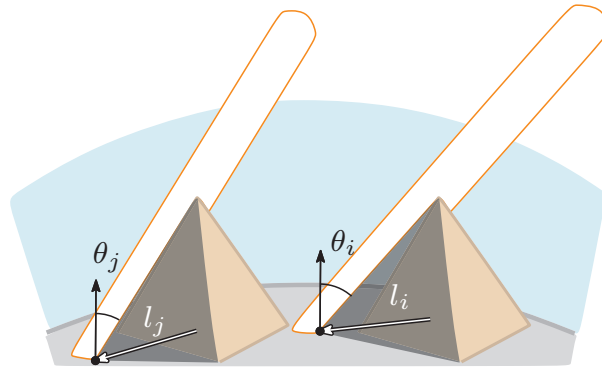
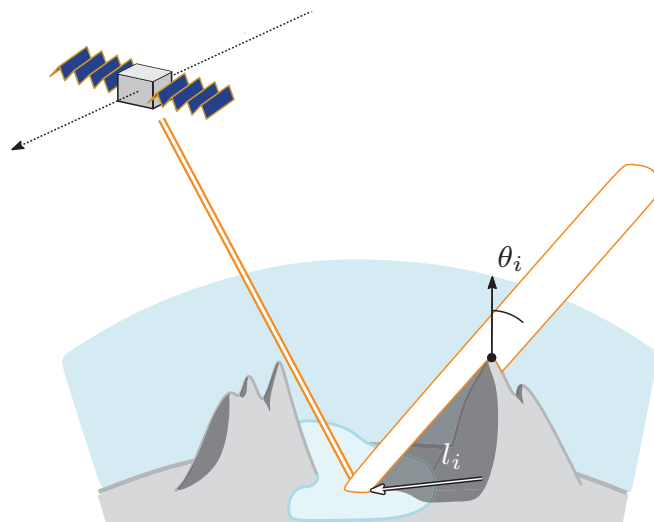# Eratosthenes (276 -195 BC) : estimates Earth's circumference

Thales (623 - 548 BC) : founder of the technique

Thales (623 - 548 BC) : from the ground, to estimate its top
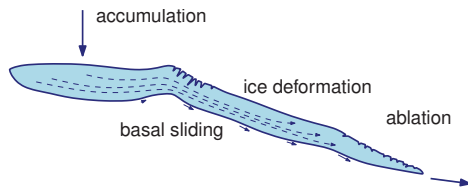
Sentinel-2 (2015 - . . . AC) : from above, estimating the surface
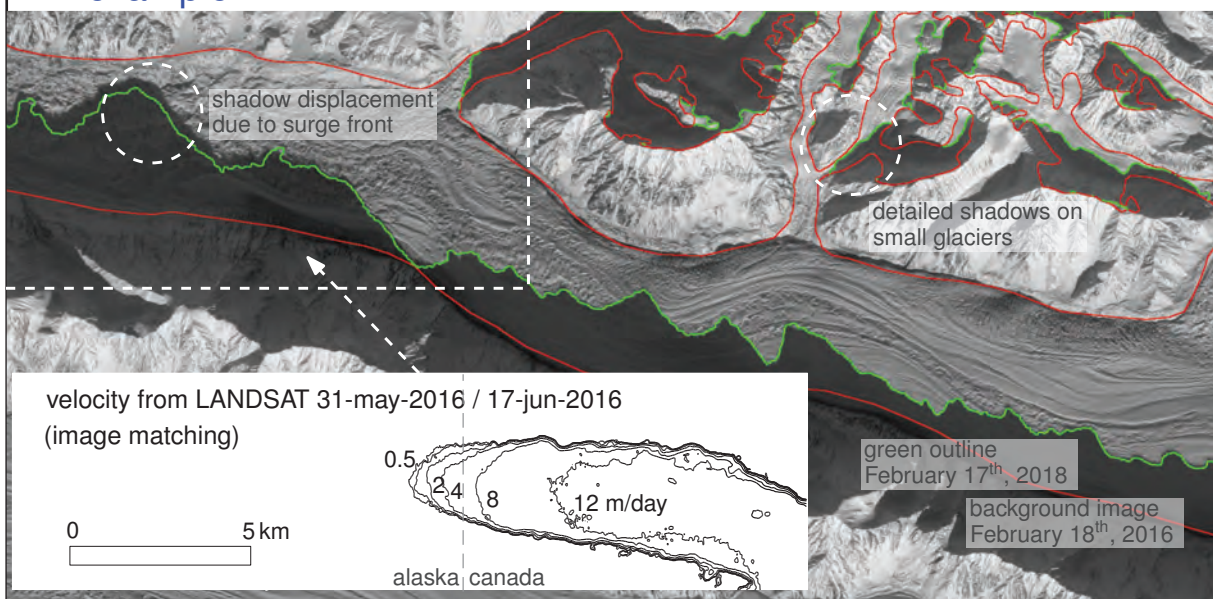
Eratosthenes in a nutshell

use satellite imagery over time,
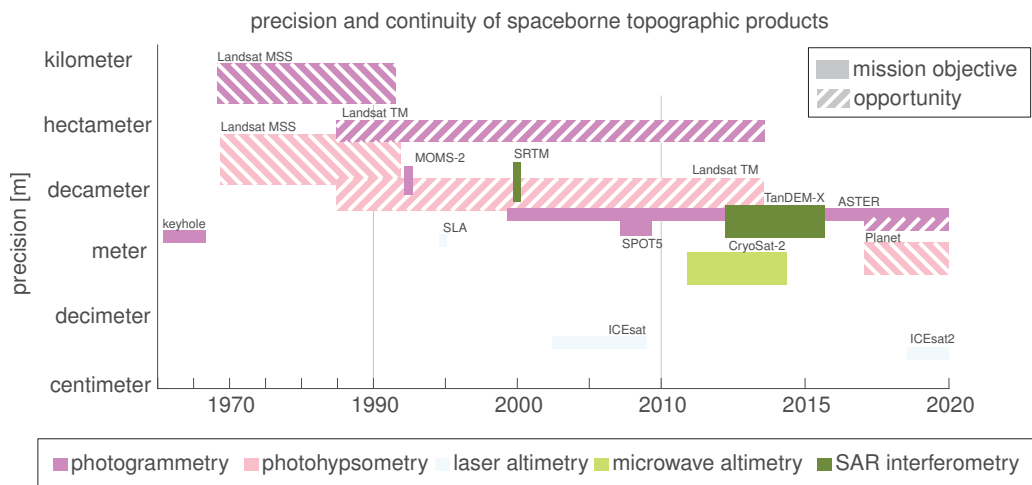extract elevation changes.

accumulation

ice deformation

basal sliding

ablation

provide measurements to glacier modellers

get better understanding of freshwater availability,
local climate & sea level rise.

An example

shadow displacement
due to surge front

detailed shadows on
small glaciers

velocity from LANDSAT 31-may-2016 / 17-jun-2016
(image matching)

0.5

2 4   8   12 m/day

0   5 km

alaska canada

green outline
February 17th, 2018

background image
February 18th, 2016

Potential in the EO archive

precision and continuity of spaceborne topographic products

Workflow

support

outlines   DEM   ephemeris

imagery   shadow detection   matching

2015...2016
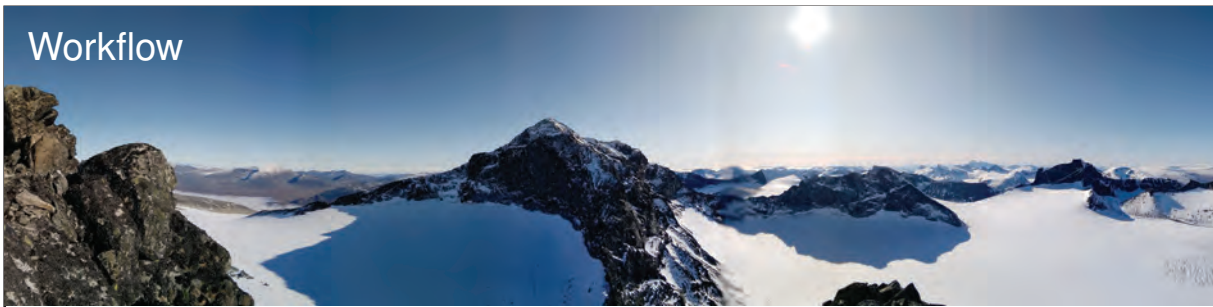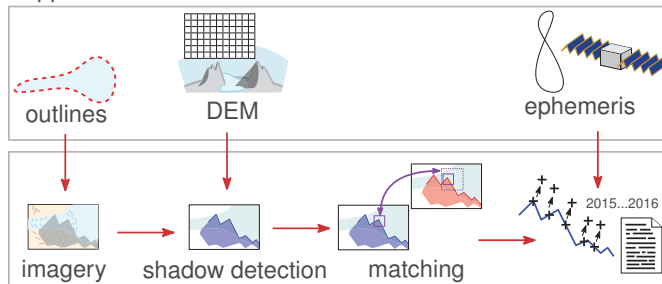
methodology

Numbers

total areal extent of glaciers is $726\,000\,\mathrm{km}^2$ (NL: $34\,000\,\mathrm{km}^2$)

covering 1797 Sentinel-2 tiles & 1927 Landsat scenes

Mission	Period	Agency
Landsat legacy	1972 -	USGS, ESA
SPOT	1986 - 2014	CNES
CBERS/IRS legacy	1999 -	INPE
RapidEye	2008 -	Planet
Sentinel-2	2016 -	ESA
SkySat	2013 - ...	Planet
Planet Dove	2016 -	Planet

Methodology: reliability test

image match

false match

sun azimuth at time2

sun-azimuth at time 1

intersect at mountain top

no intesect at shadow polygon
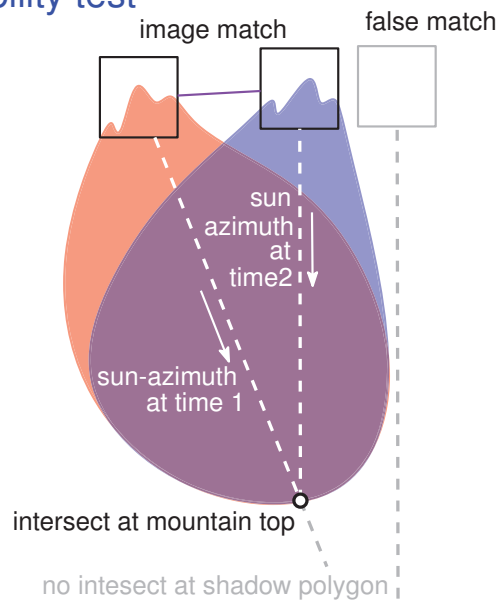
Methodology: overview and example

Ötztaler Alpen

T

C_1

CT

C_2

dH

C_1C_2

Landsat 5 TM - 27 Dec 1988
Landsat 5 TM - 05 Jan 1998
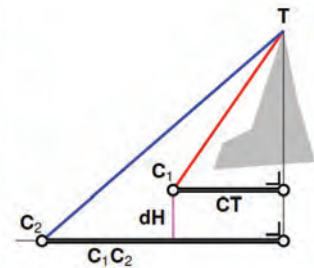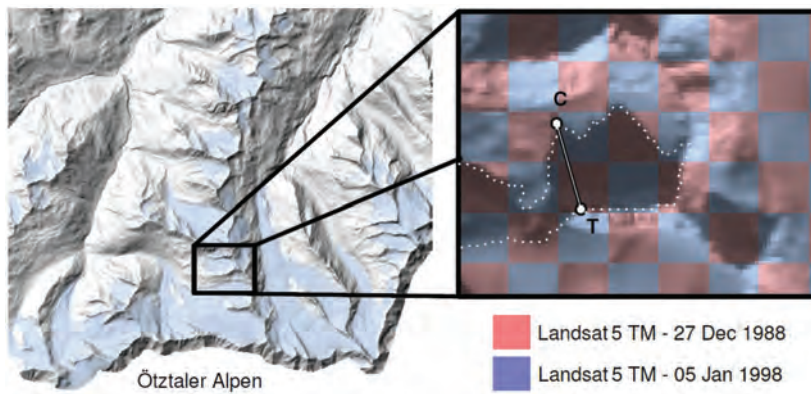
Configurations to extract topography