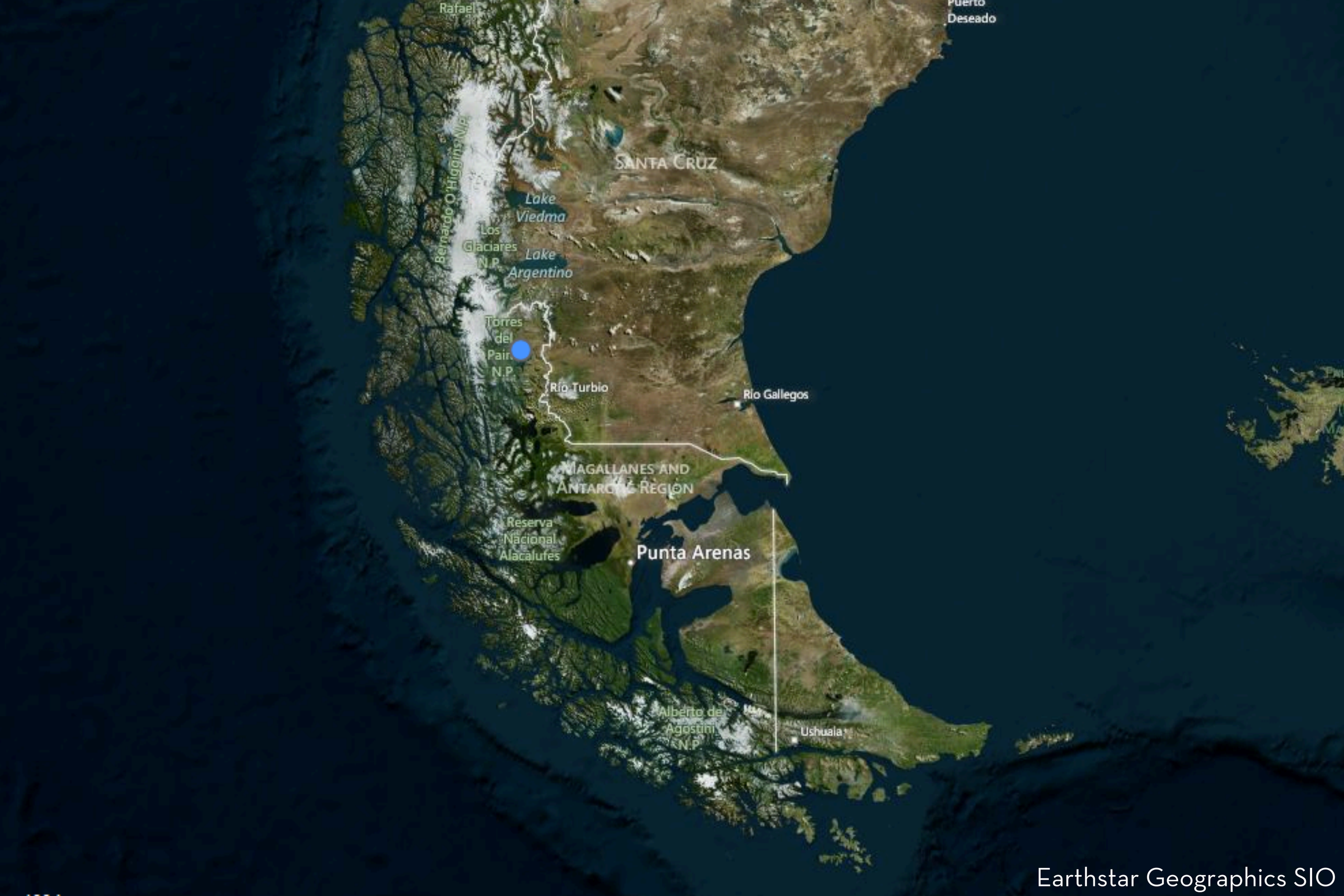
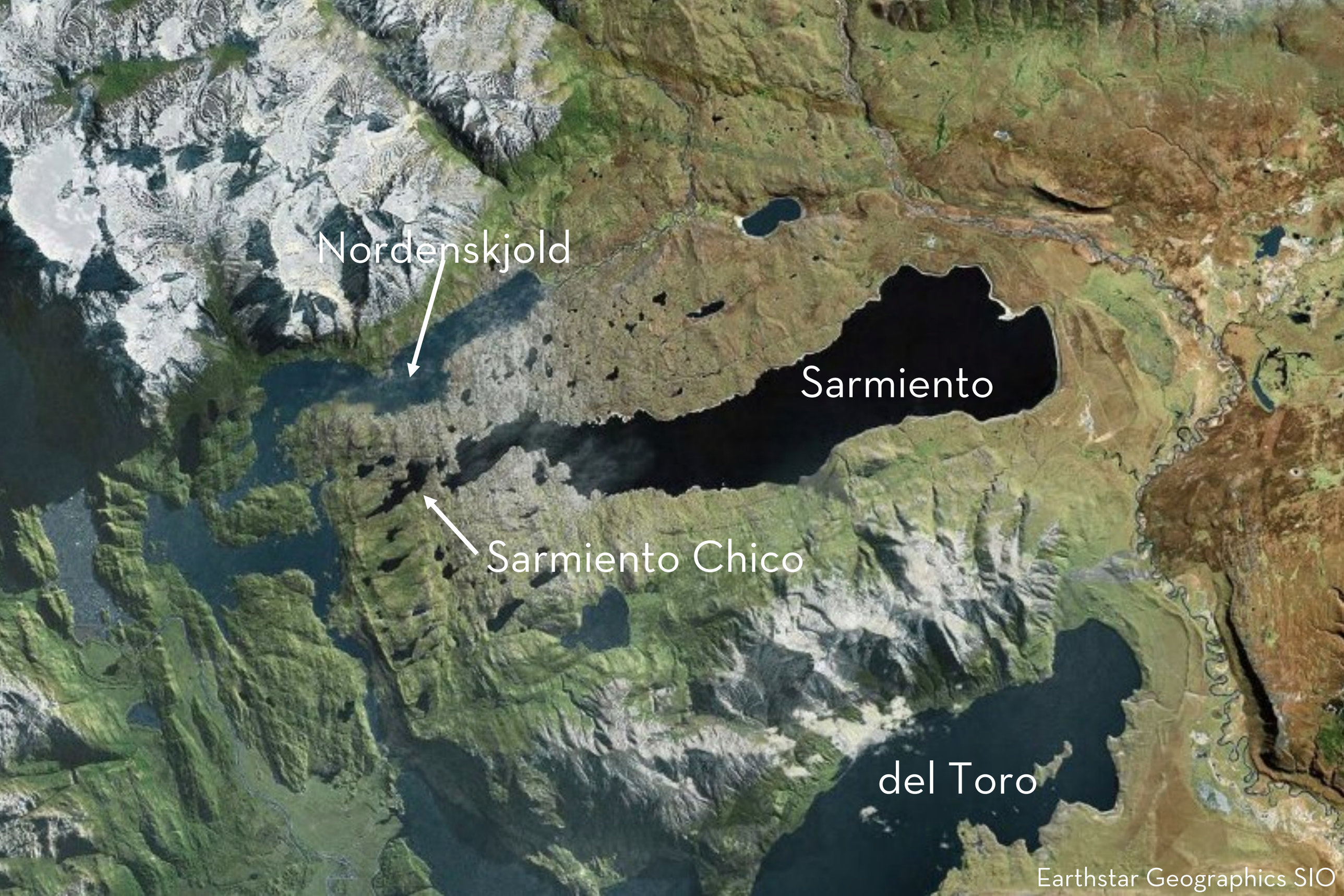
Building a Hydrologic Model of Lago Sarmiento in Southern Chile

Caleb Kruse
Mentors: Rob Dunbar and Sverre LeRoy

PATAGONIA



Earthstar Geographics SIO


Nordenskjold
Sarmiento
Sarmiento Chico
del Toro
Earthstar Geographics SIO

W

Photo: Sverre LeRoy

$\delta^{18}O$ (‰)

Lake Level↑ $\delta^{18}O$↓

Lake Level↓ $\delta^{18}O$↑

Talbot, M. (1990). Chemical Geology: Isotope Geoscience Section, 80(4), 261–279.

Modeling

Inputs

Climate

Precipitation
Air Temperature
Relative Humidity
Wind Speed

Physical

Lake Elevation
Latitude
Basin Topography
Lake Bathymetry

$$\frac{dV_{lake}}{dt} = V_{inflow} + P_{lake} - E + G$$

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$$E_{Linacre} = 30(0.015 + 4 \times 10^{-4} \cdot T + 10^{-6} z)\left[\frac{480(T + .006z)}{84 - |Lat|}\right] - 40 + 2.3 \cdot Wind(T - T_d)$$

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$$Magnus\ T_d = \frac{243.5^\circ C \cdot \ln(RH\%) + \dfrac{17.67 \cdot T}{243.5^\circ C + T}}{17.67 - \ln(RH\%) + \dfrac{17.67 \cdot T}{243.5^\circ C + T}}$$

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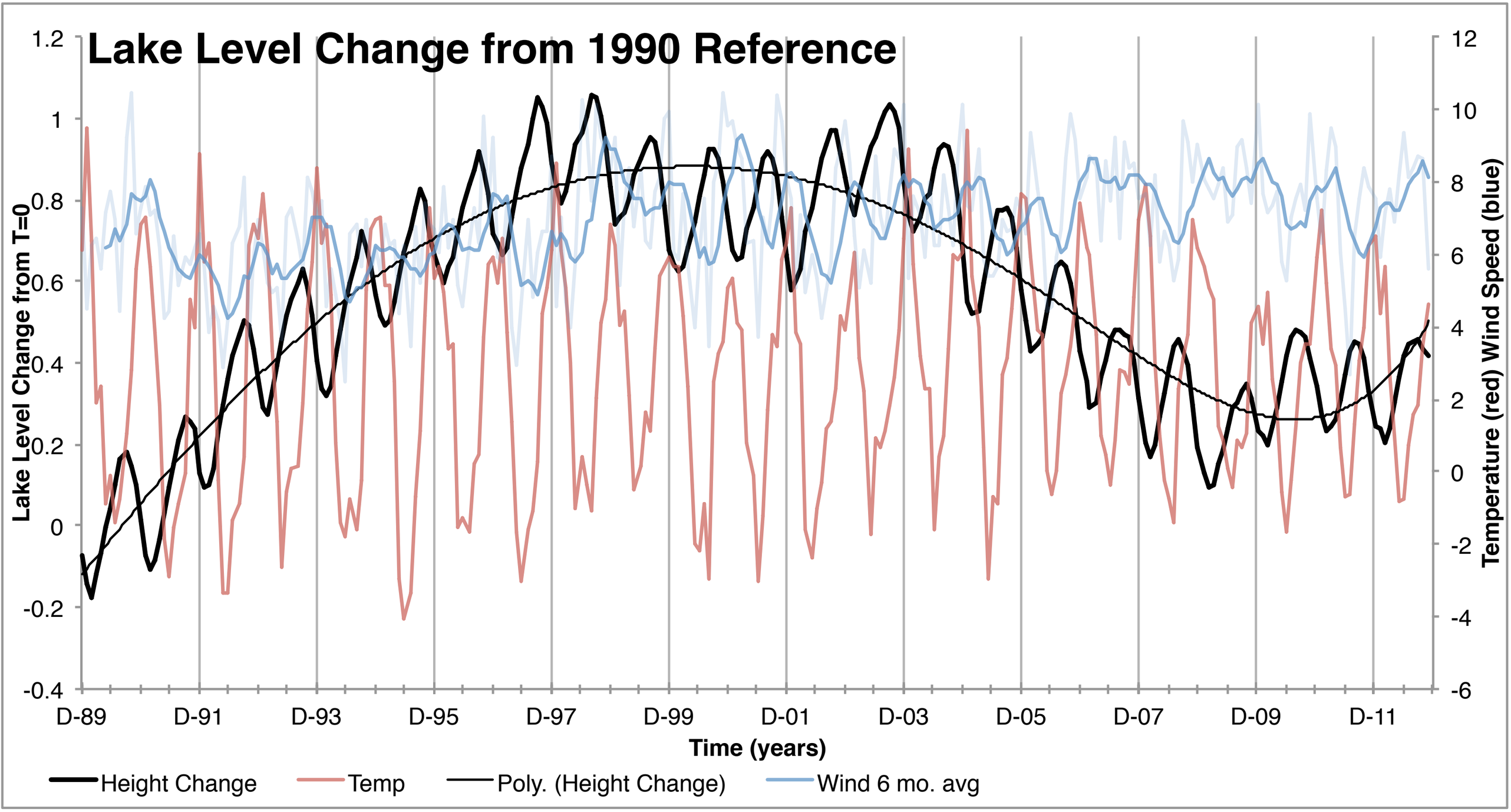
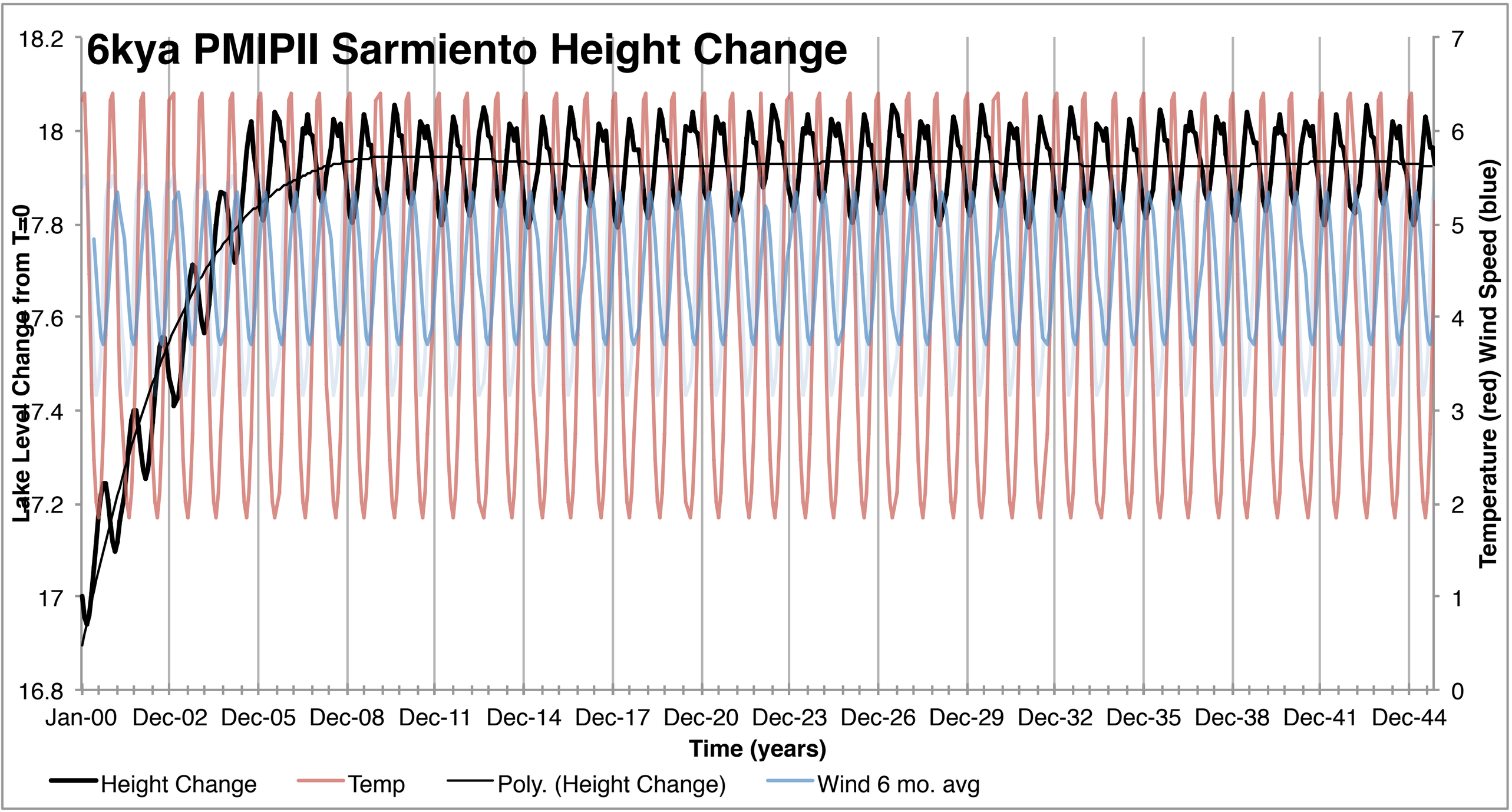
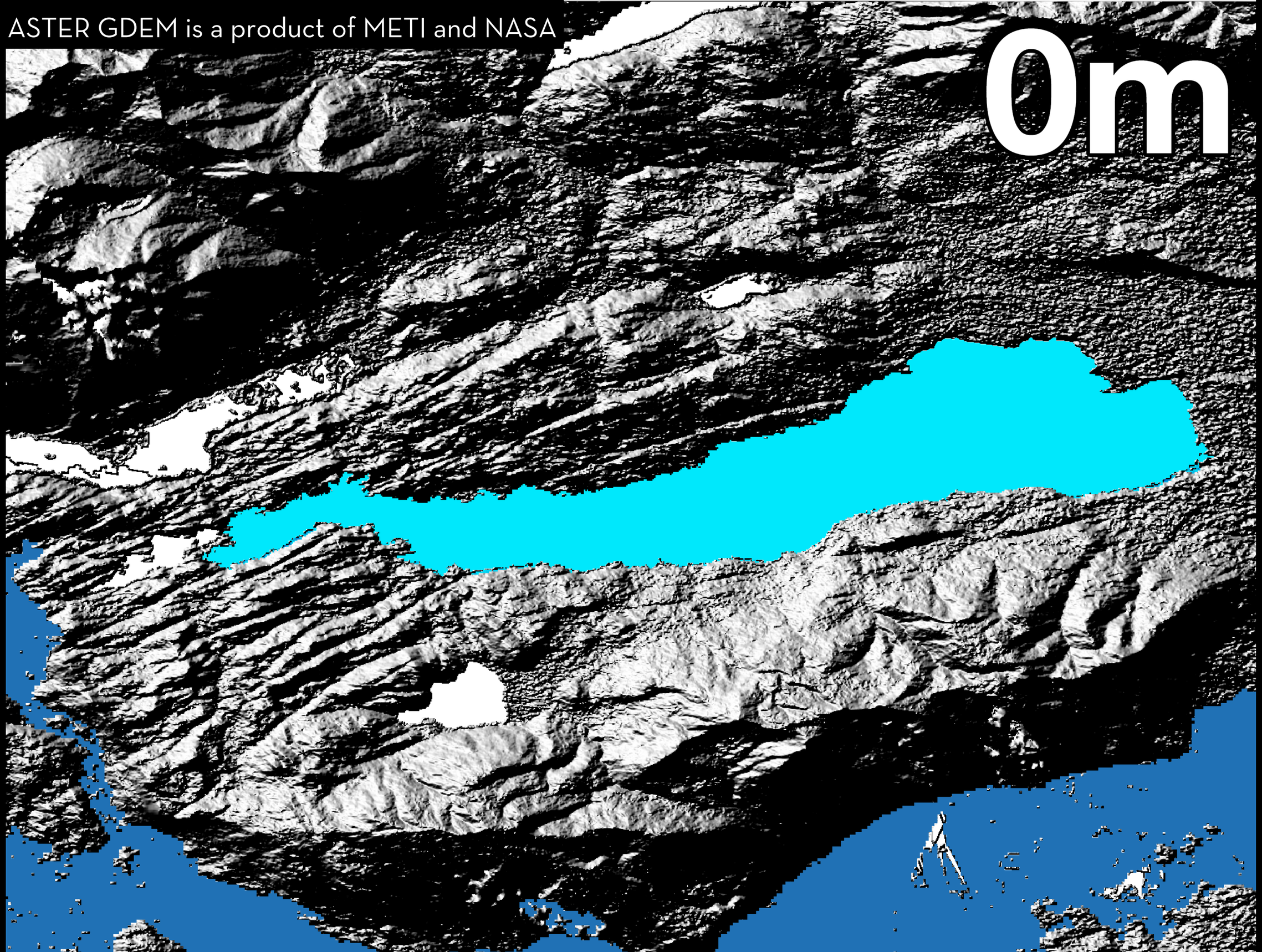
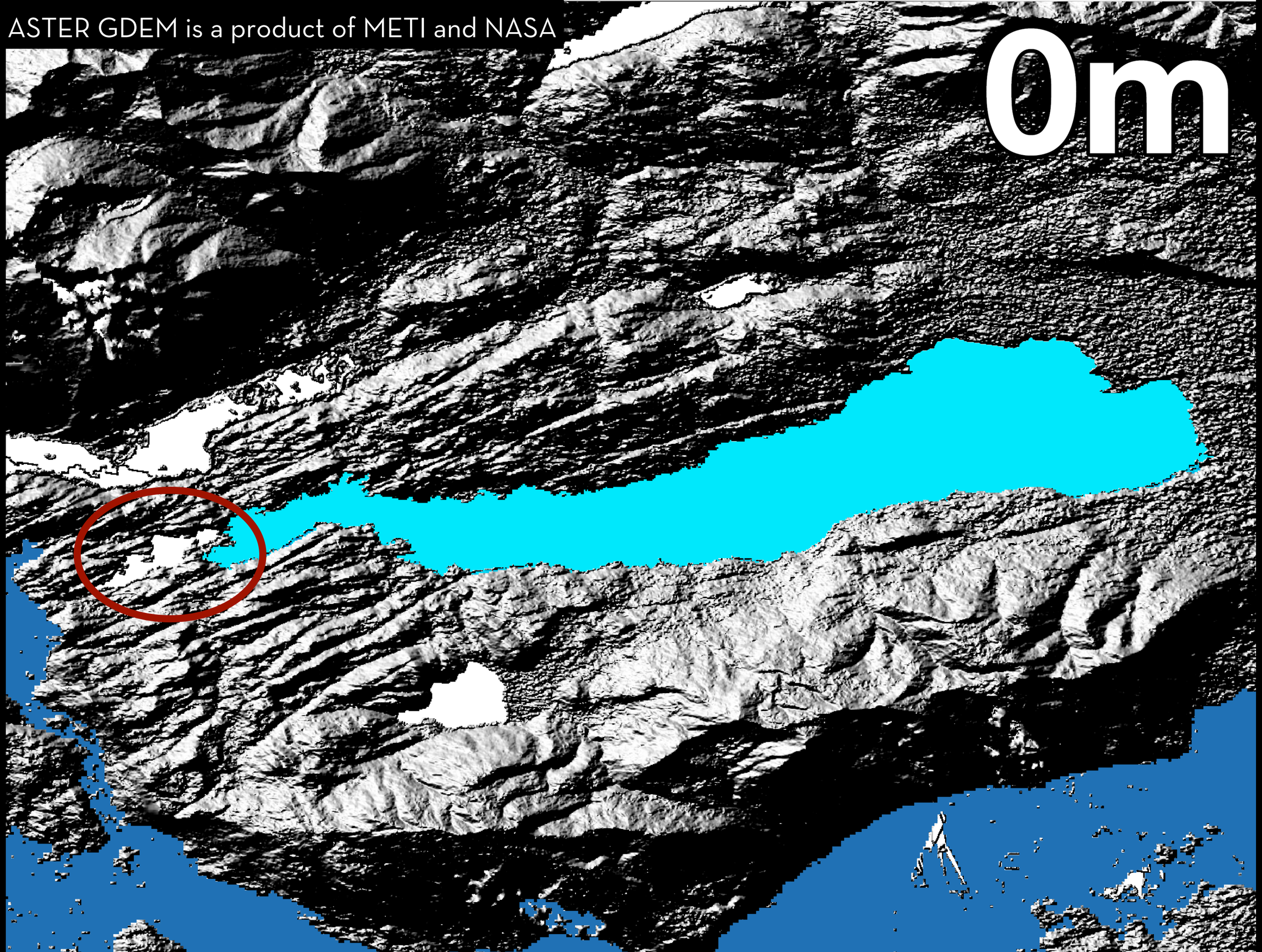
$$Lake\ Surface\ Area = \begin{cases} 1.89 \times 10^9 + z \cdot 7.99 \times 10^8 & z > 18 \\ 8.3 \times 10^7 + z \cdot 9.511 \times 10^4 & 0 < z < 18 \\ \pi\left[\mathrm{r} + (\Delta z / slope)\right]^2 & 0 \geq z \geq -350 \end{cases}$$


Lake Level Change from 1990 Reference
Lake Level Change from T=0
Temperature (red) Wind Speed (blue)
Time (years)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
12
10
8
6
4
2
0
-2
-4
-6
D-89
D-91
D-93
D-95
D-97
D-99
D-01
D-03
D-05
D-07
D-09
D-11
Height Change
Temp
Poly. (Height Change)
Wind 6 mo. avg


6kya PMIPII Sarmiento Height Change
Lake Level Change from T=0
Temperature (red) Wind Speed (blue)
Time (years)
18.2
18
17.8
17.6
17.4
17.2
17
16.8
7
6
5
4
3
2
1
0
Jan-00
Dec-02
Dec-05
Dec-08
Dec-11
Dec-14
Dec-17
Dec-20
Dec-23
Dec-26
Dec-29
Dec-32
Dec-35
Dec-38
Dec-41
Dec-44
Height Change
Temp
Poly. (Height Change)
Wind 6 mo. avg

ASTER GDEM is a product of METI and NASA




ASTER GDEM is a product of METI and NASA
0m

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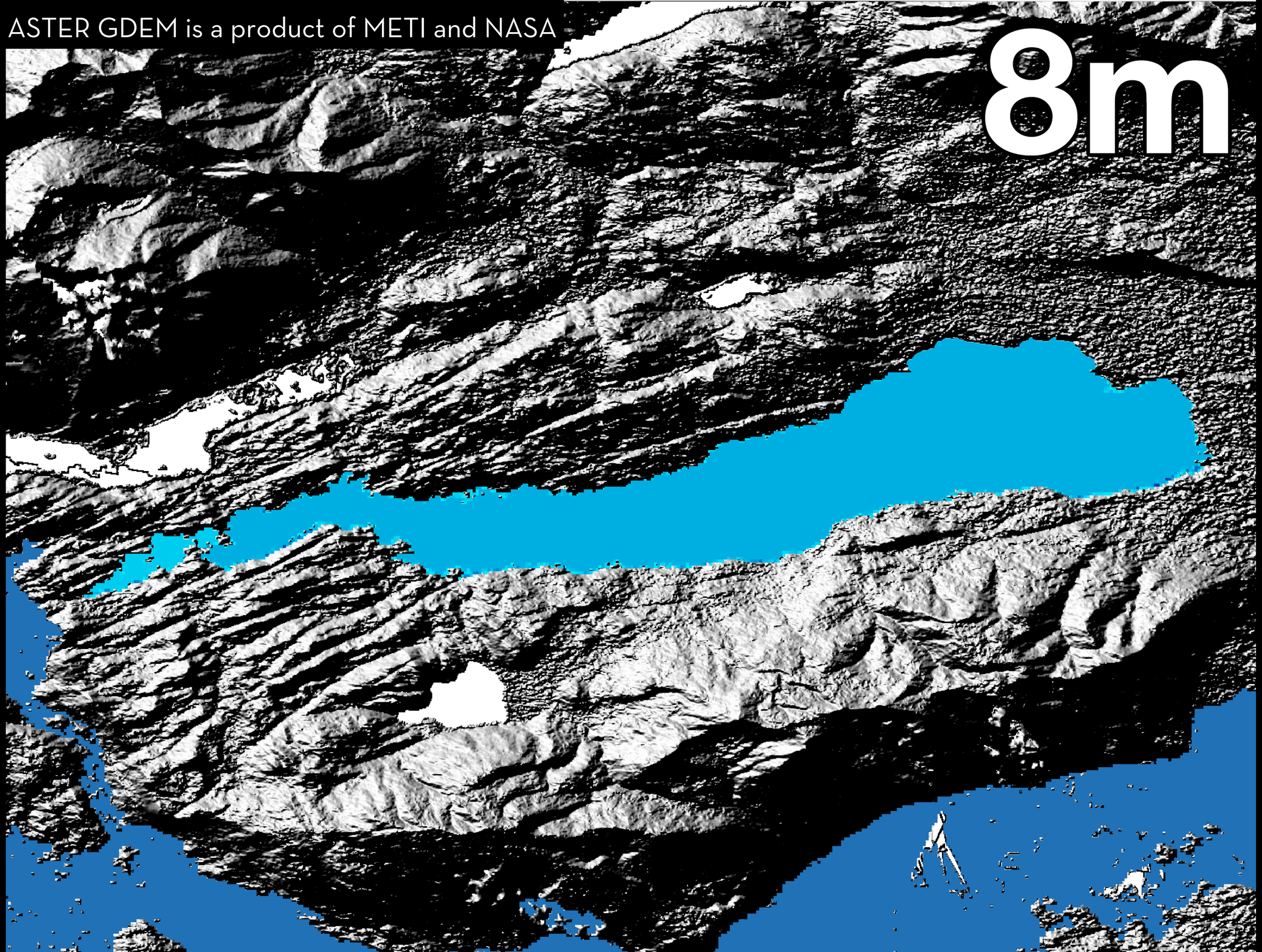

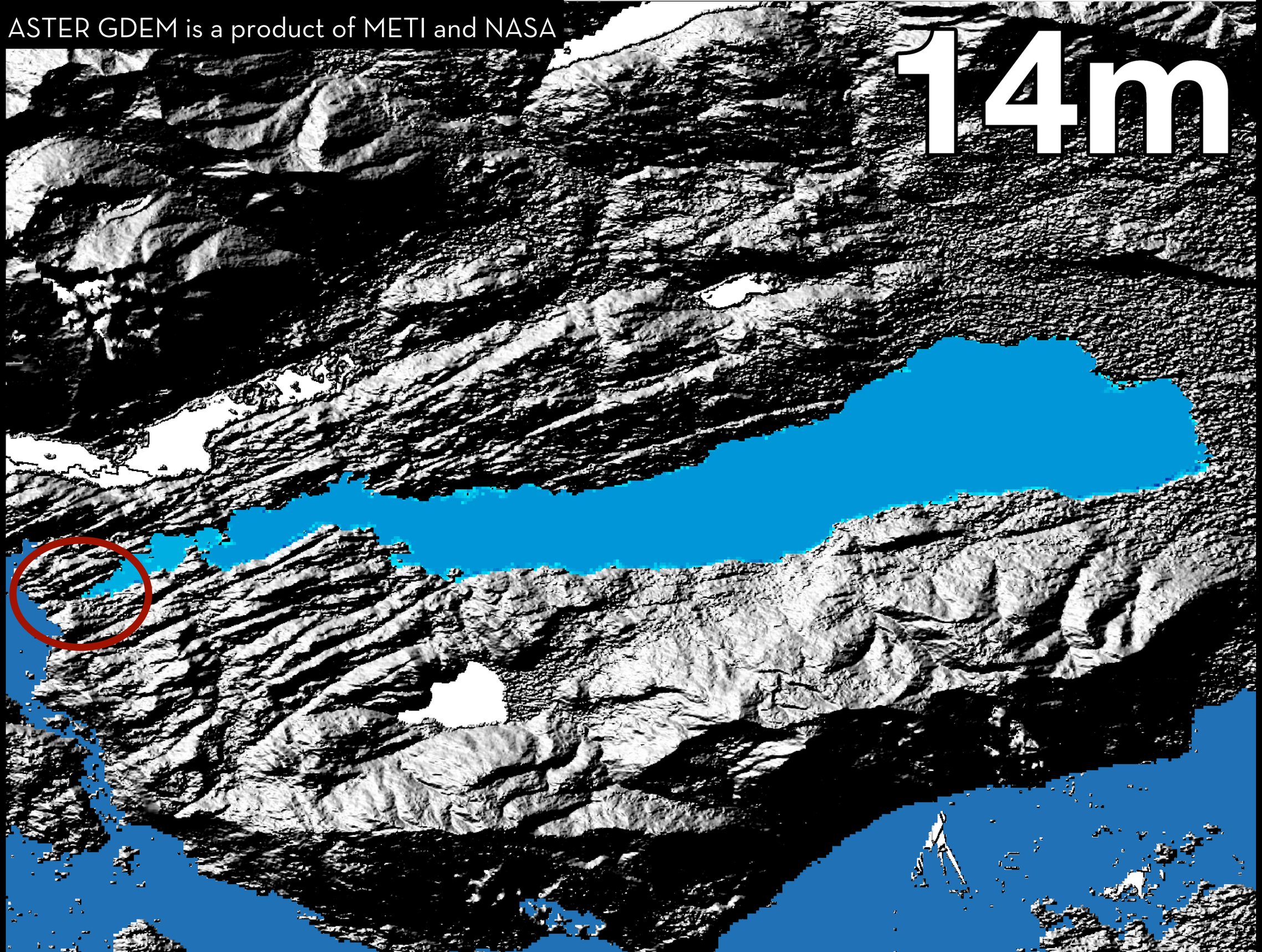
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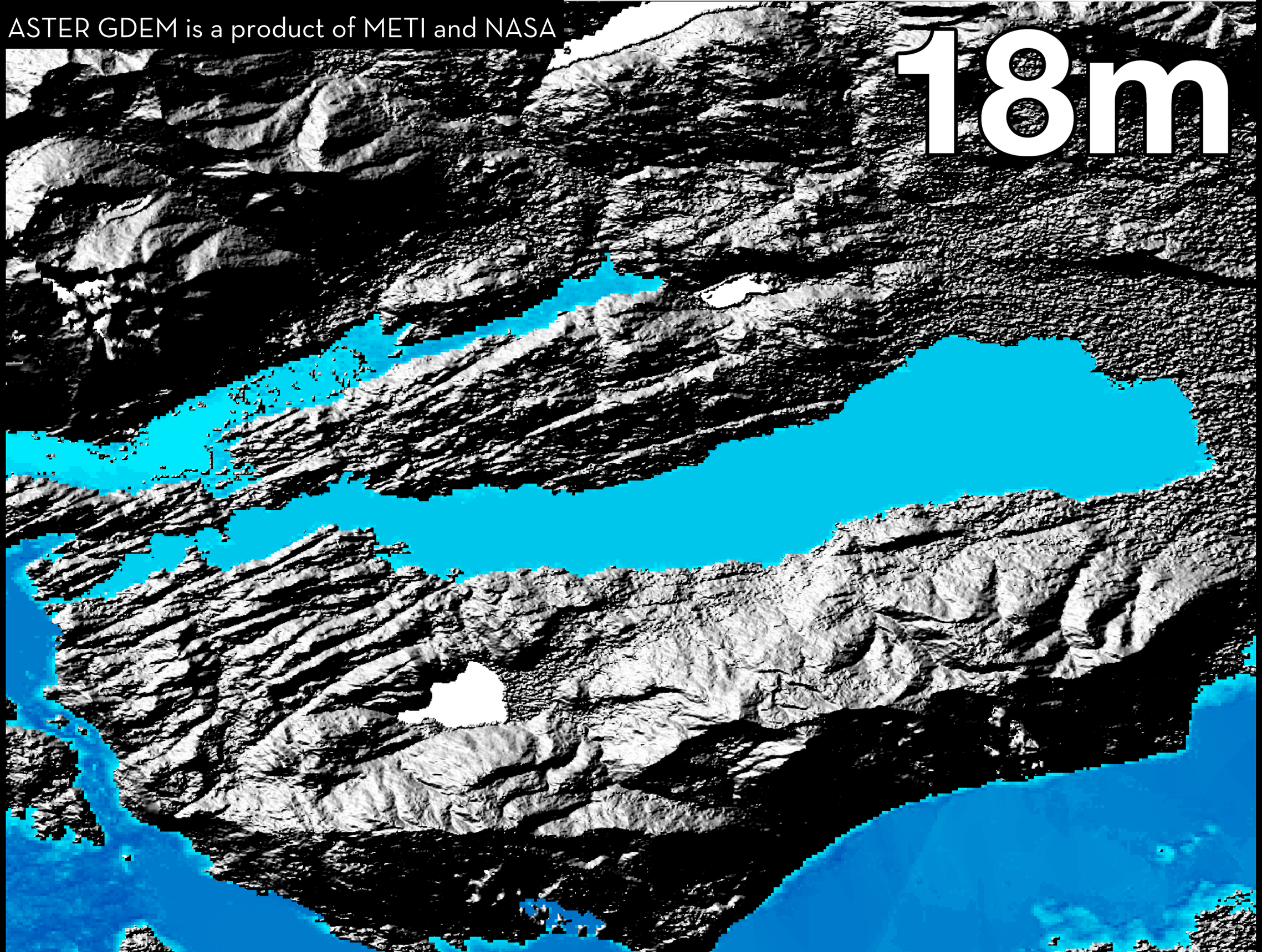
14m


ASTER GDEM is a product of METI and NASA
18m

ASTER GDEM is a product of METI and NASA

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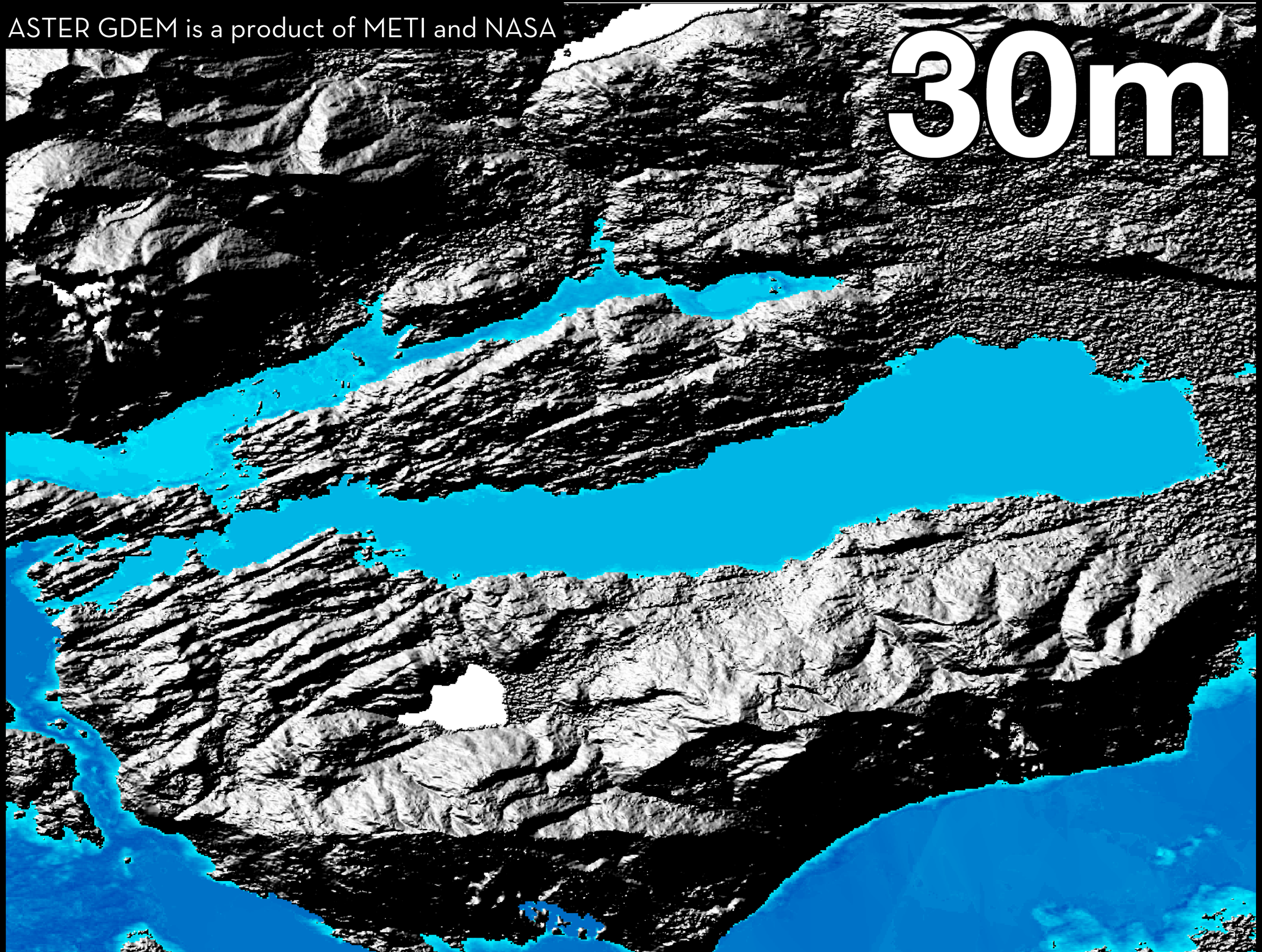
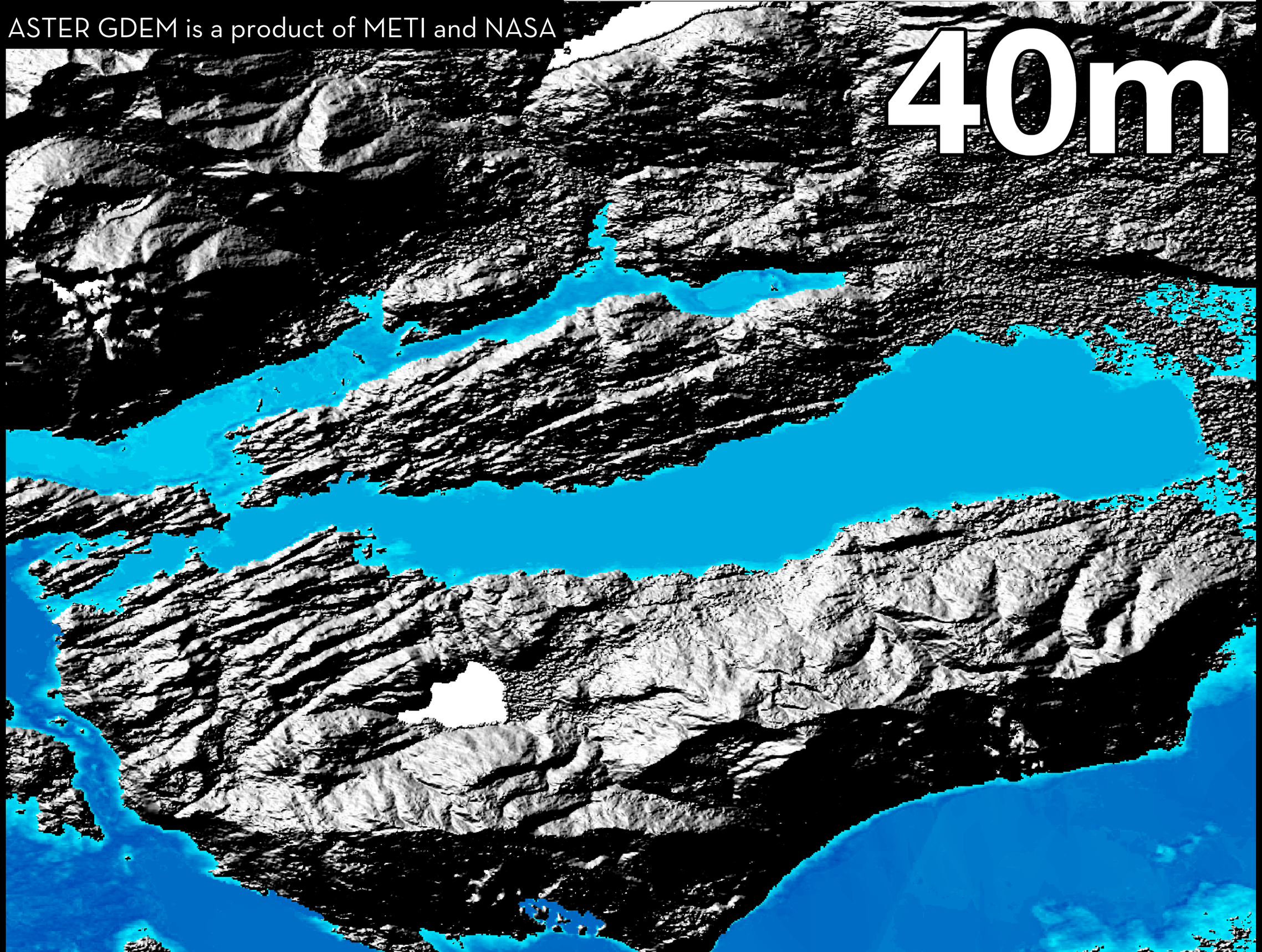
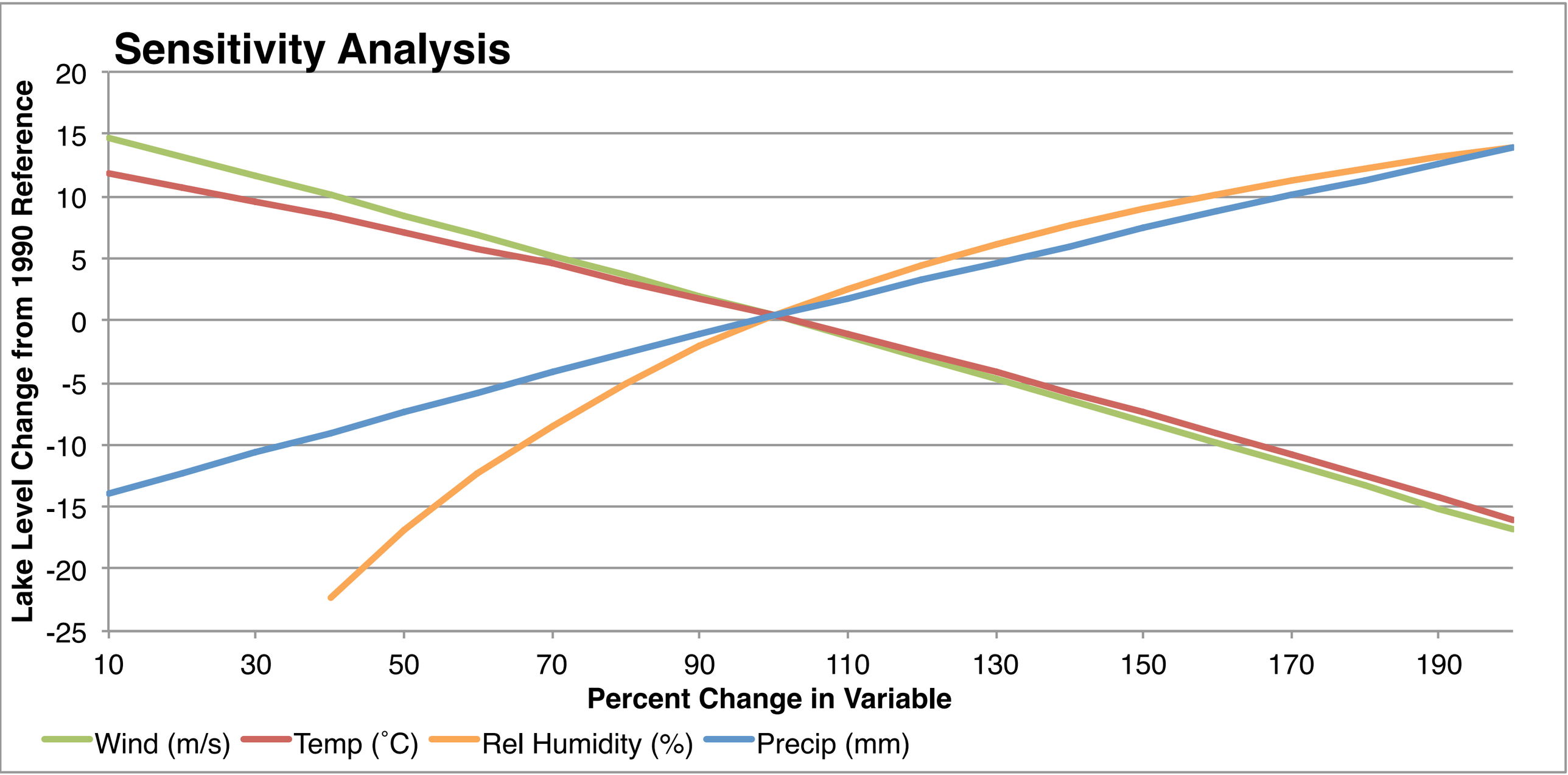
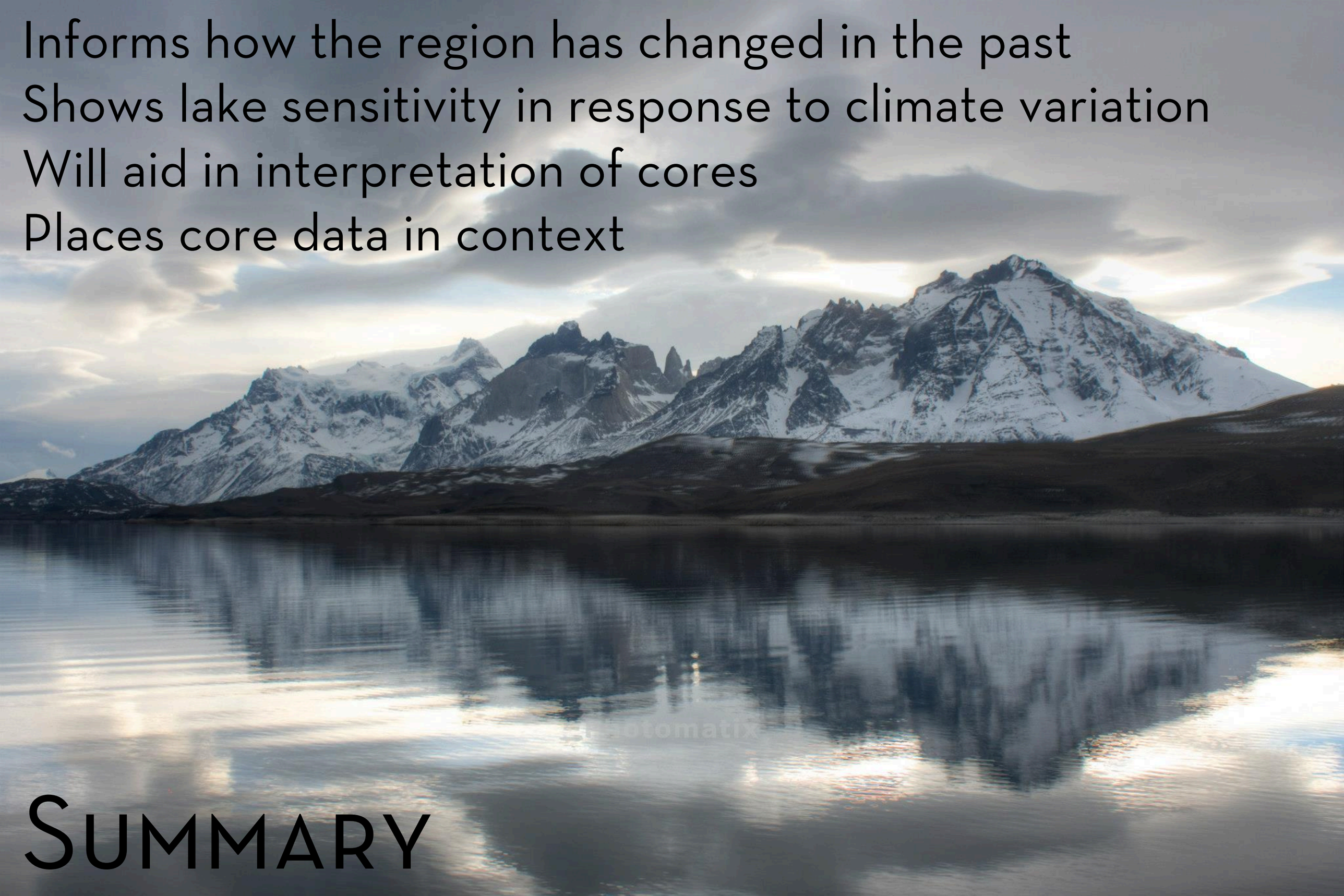



ASTER GDEM is a product of METI and NASA
40m


Sensitivity Analysis
Lake Level Change from 1990 Reference
20
15
10
5
0
-5
-10
-15
-20
-25
10
30
50
70
90
110
130
150
170
190
Percent Change in Variable
Wind (m/s)
Temp (˚C)
Rel Humidity (%)
Precip (mm)



Informs how the region has changed in the past
Shows lake sensitivity in response to climate variation
Will aid in interpretation of cores
Places core data in context

Summary