

ESS 533 / ATMS 512

Dynamics of Ice and Snow

Learning Objectives

- You will develop an appreciation of ice as the most dynamic solid surface on planet Earth.
- You will understand processes controlling ice motion.
- You will be able to calculate or predict ice motions using a variety of simple approximations.
- You will develop an appreciation of the advances in ice dynamics since c1950.

Global Ice Characteristics

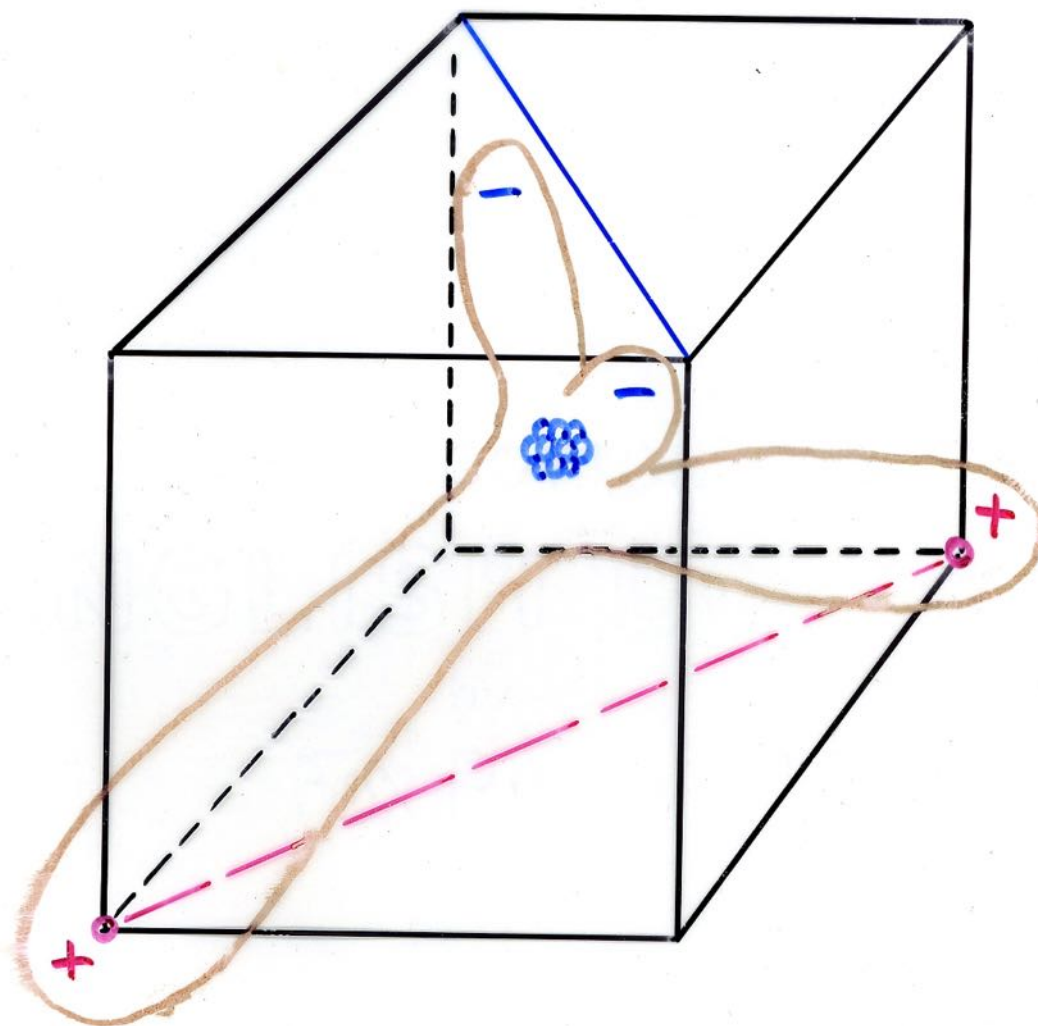
Land ice	Area (10^6 km^2)	Thickness (km)	Volume (10^6 km^3)	Sea-level Equiv (m)
East Ant	9.9	2.6	25.9	50
West Ant	2.1	1.6	3.4	3.3
Greenland	1.8	1.5	2.7	7
The Rest	0.6	0.3	0.2	0.5

Sea ice		(m)	(10^3 km^3)	
Antarctic max	20	1.5	30	0
min extent	2.5	2.0	5	0
Arctic max	15	3.3(1.8)	50(27)	0
min extent	8.5(2.8)	2.4(2.0?)	20(6)	0

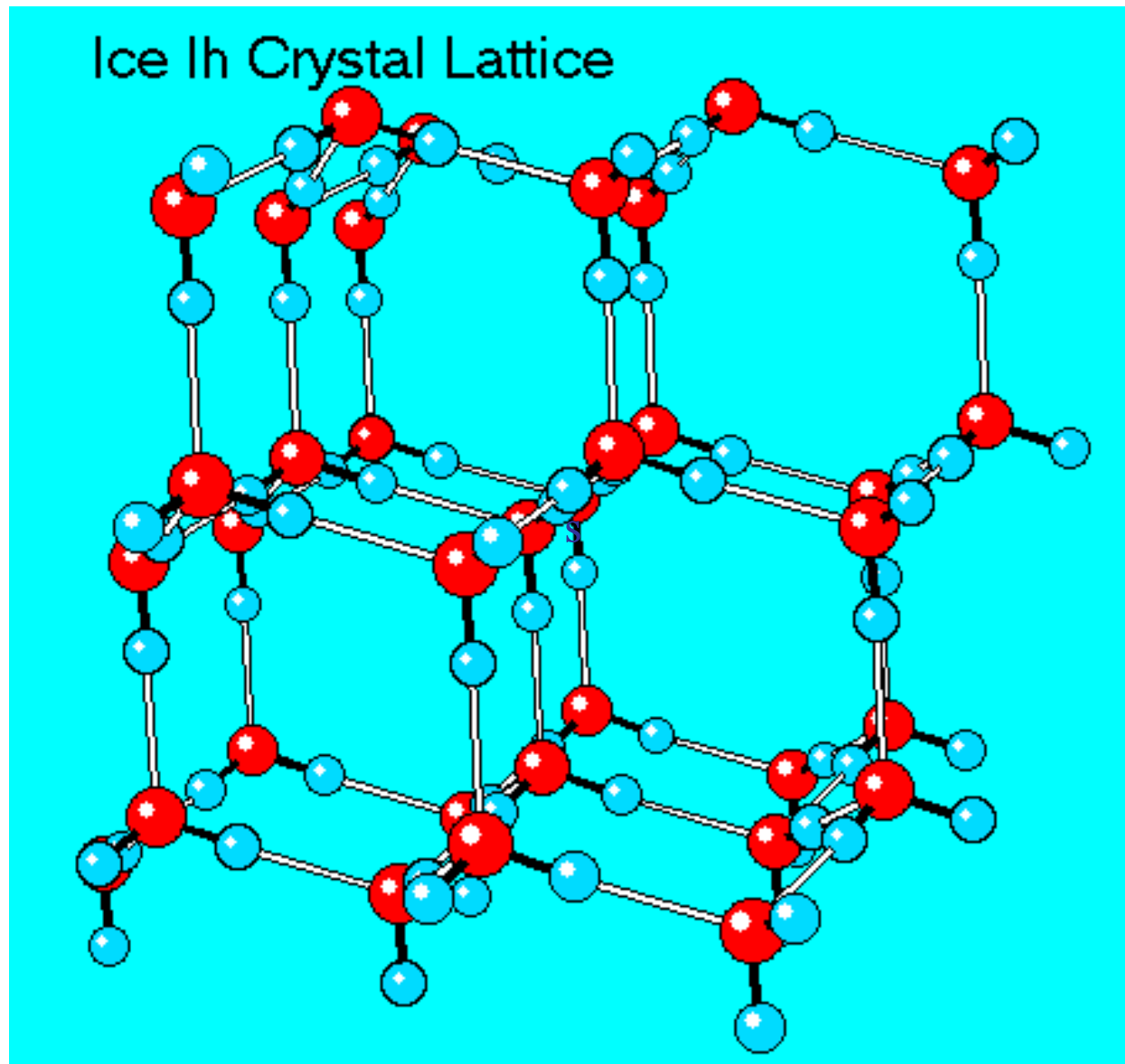
Seasonal snow

January 45

Tetrahedral Structure of H₂O Molecule



Ice Lattice



<http://www.its.caltech.edu/~atomic/snowcrystals/ice/ice.htm>

Hexagonal Form of Ice

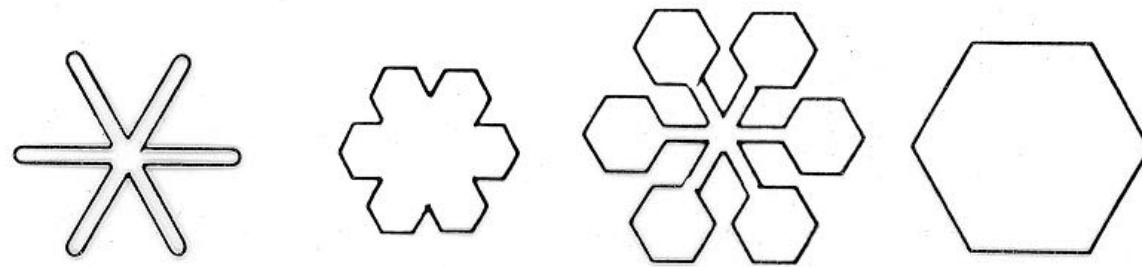


Figure 10. Hexagonal shape of snow flakes.

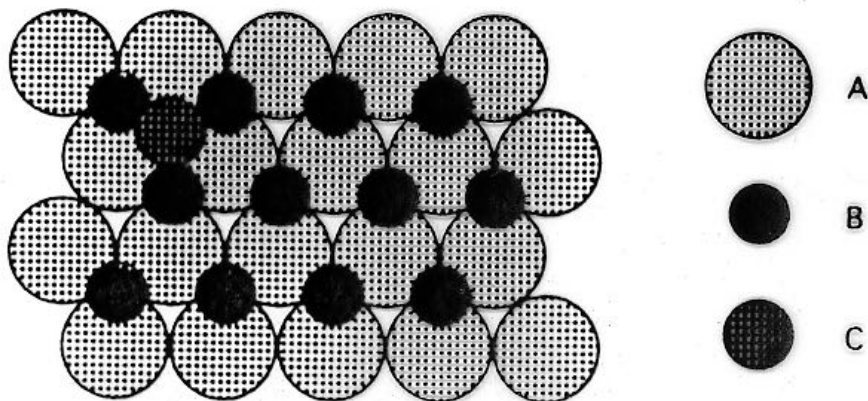
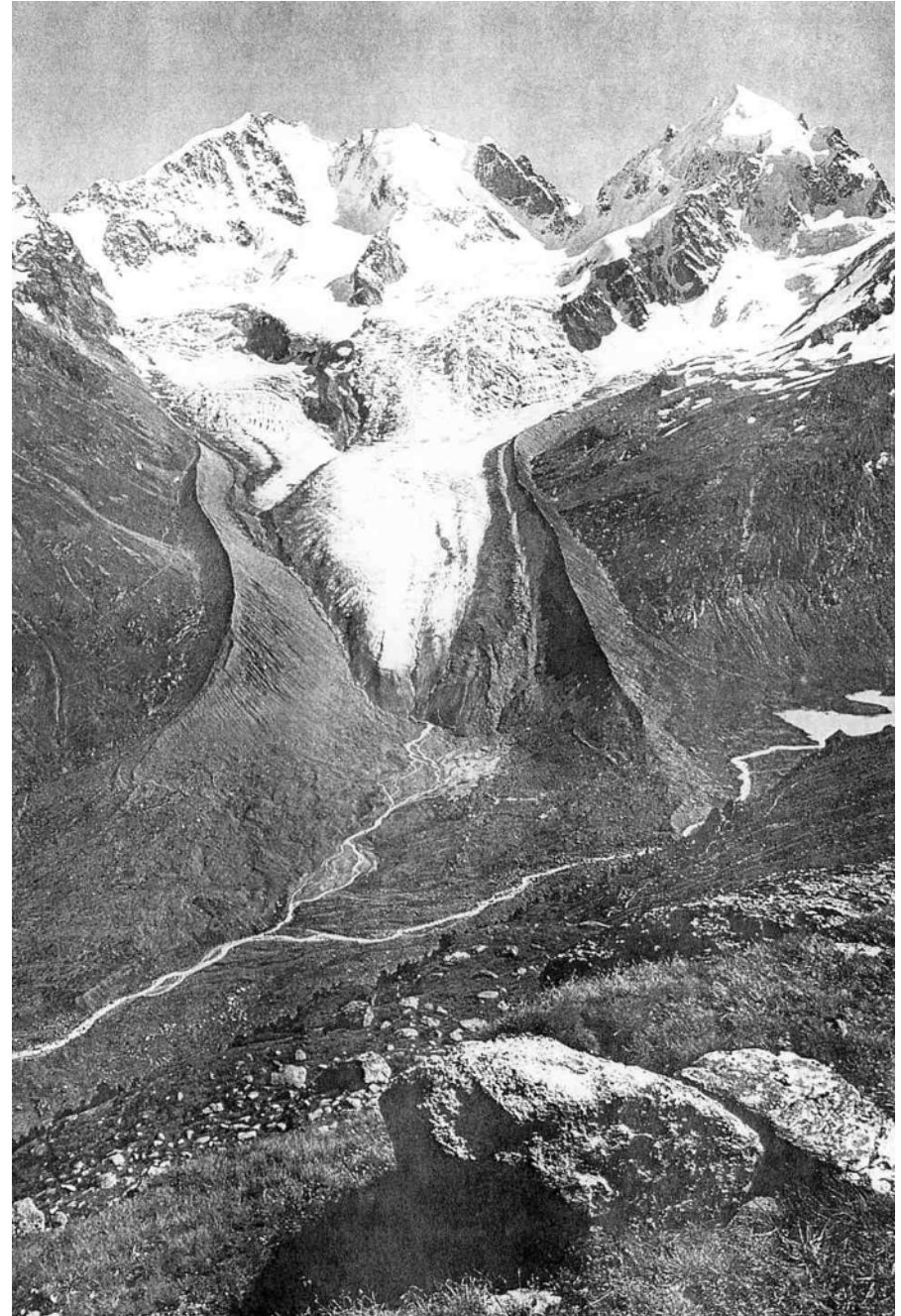


Figure 11. Dense packing of identical, ideal balls on a level surface.

What is this?

Is there anything
dynamic here?



What is this?

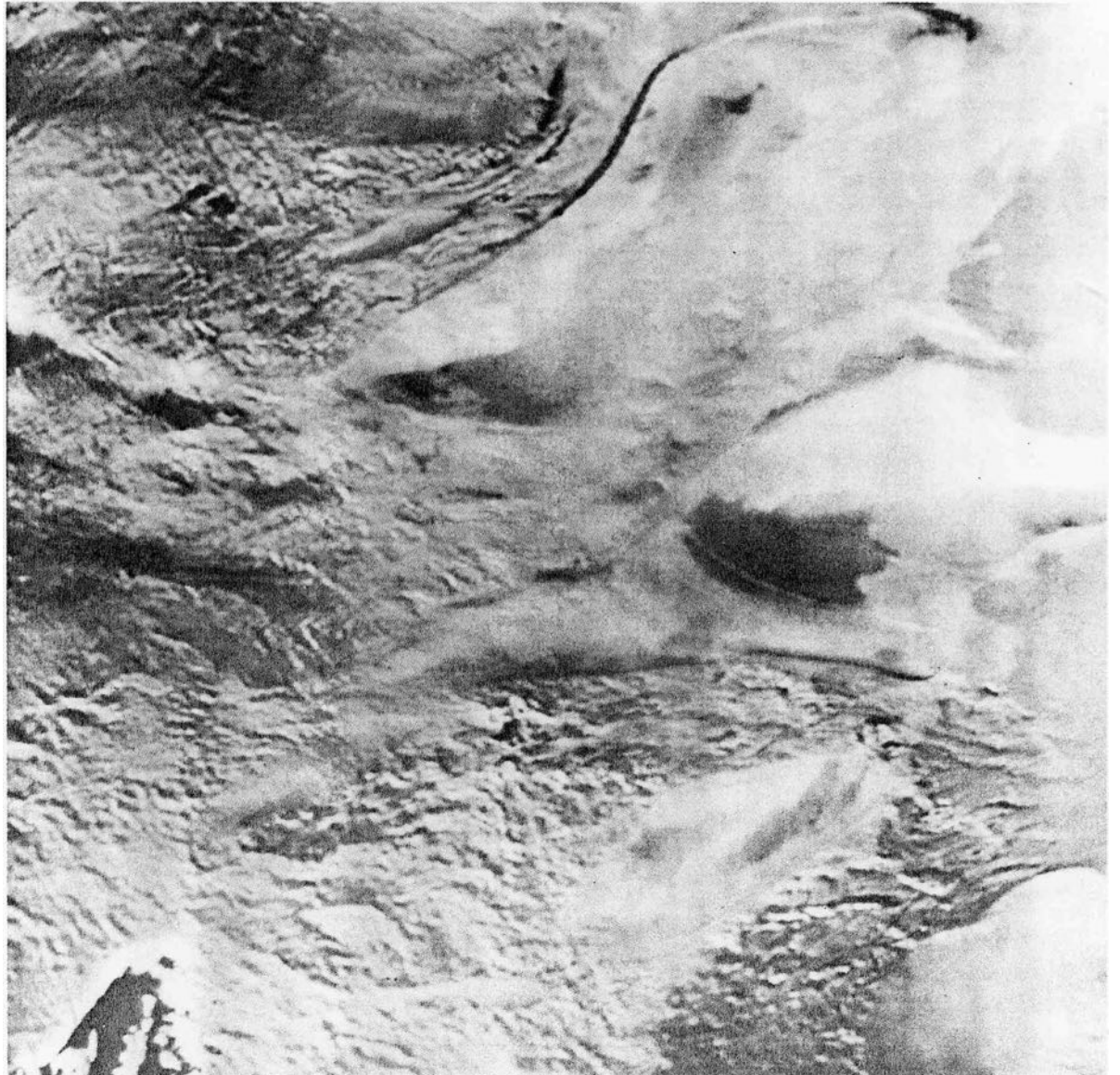


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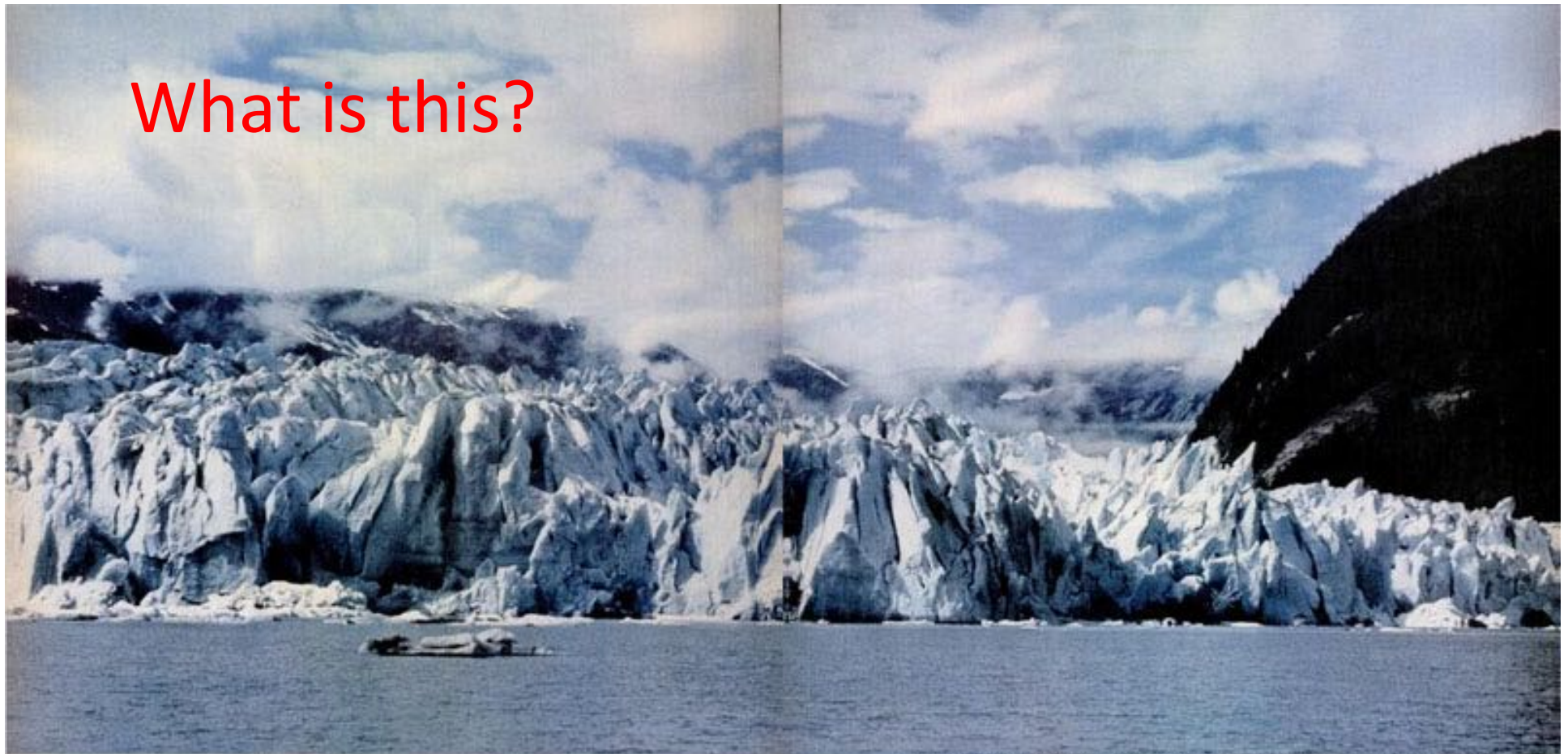
EOS

Transactions, American Geophysical Union
Vol. 71 No. 23 June 5, 1990



Is there anything
dynamic here?

What is this?



PERITO MORENO GLACIER, ARGENTINA, IS A RIVER OF ICE STRETCHING 270 SQUARE MILES. YET THE PETROLEUM ENERGY HUMBLE SUPPLIES AMERICA TODAY MELT IT AT THE RATE OF 7 MILLION TONS A DAY!

EACH DAY HUMBLE SUPPLIES ENOUGH **ENERGY** TO MELT 7 MILLION TONS OF GLACIER!

This giant glacier has remained unmelted for centuries. Yet, the petroleum energy Humble supplies—if converted into heat—could melt it at the rate of 80 tons each second! To meet the nation's growing needs for energy, Humble has applied science to nature's resources to become America's Leading Energy Company. Working wonders with oil through research, Humble provides energy in many forms—to help heat our homes, power our transportation, and to furnish industry with a great variety of versatile chemicals. Stop at a Humble station for new Enco Extra gasoline, and see why the "Happy Motoring" Sign is the World's First Choice!

HUMBLE
OIL & REFINING COMPANY
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Is there anything
dynamic here?

LIFE, 2 February 1962

What is
this?

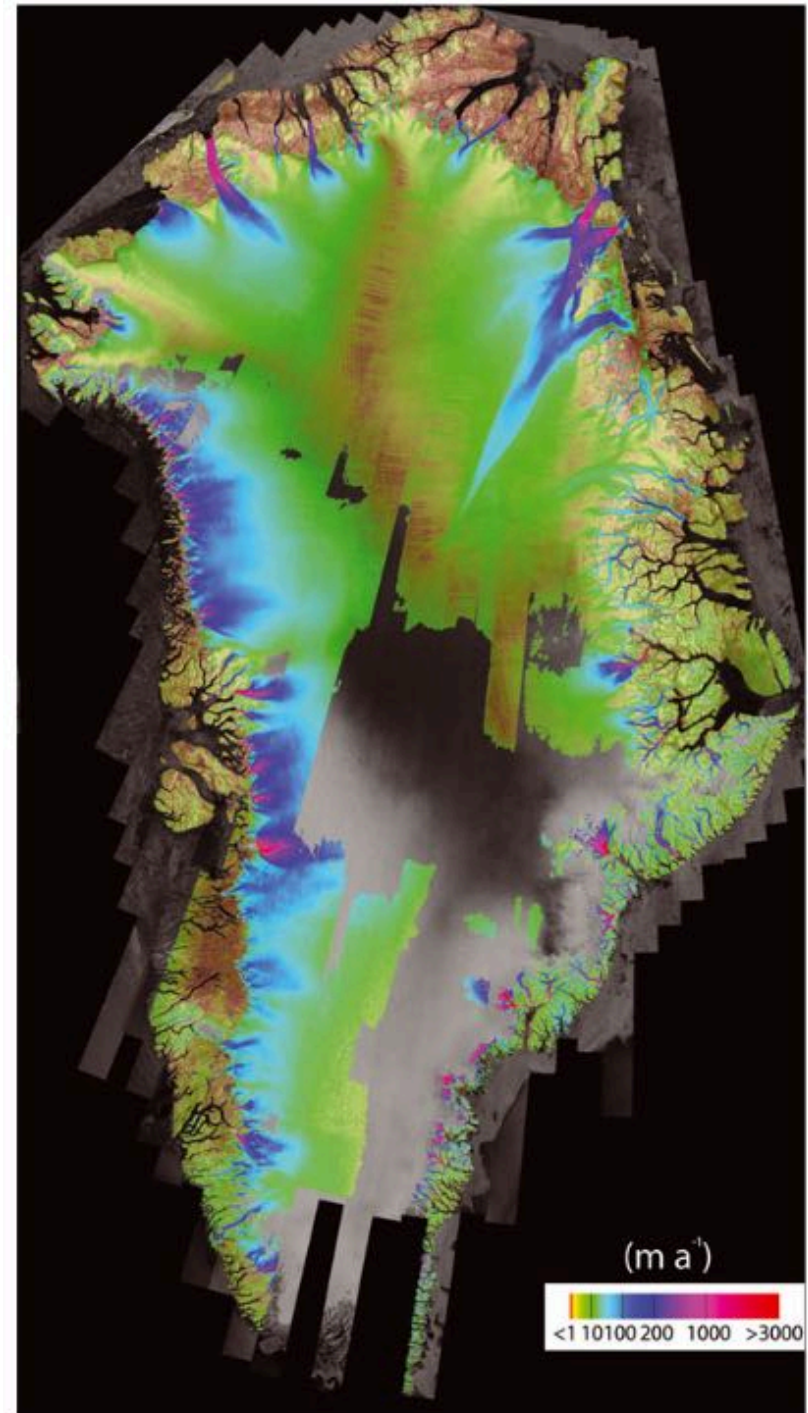


Is there anything dynamic here?

What is this?

Speed in 2005/06 winter derived from a combination of interferometric phase and speckle tracking.

Adapted from Joughin et al., (2010), *J. Glaciol.* 200(56), 1026-1042.



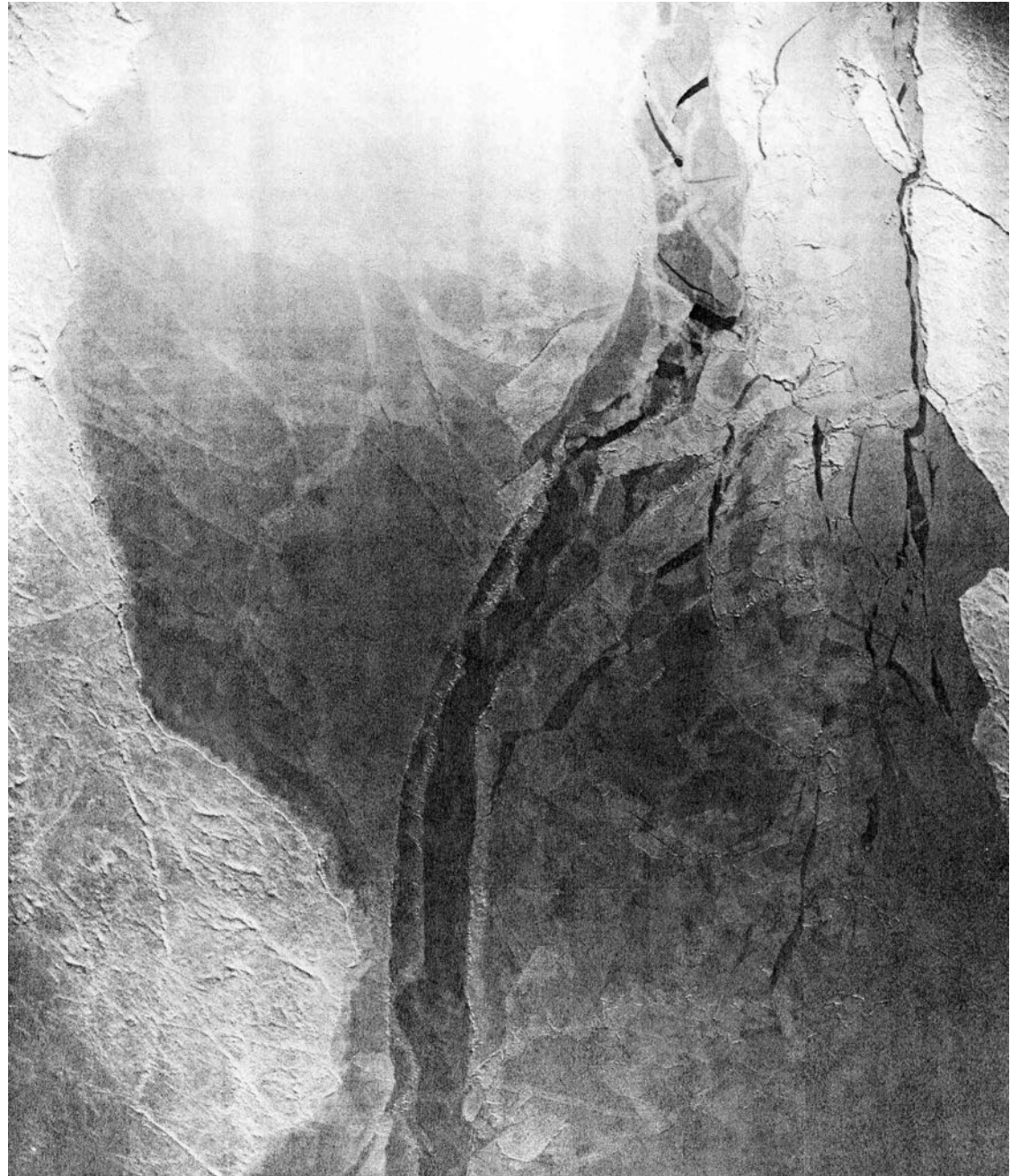
What is this?

<http://www.youtube.com/watch?v=4JL6b3vGIkU&NR=1>

<https://www.youtube.com/watch?v=hC3VTgIPoGU>

Is there anything dynamic here?

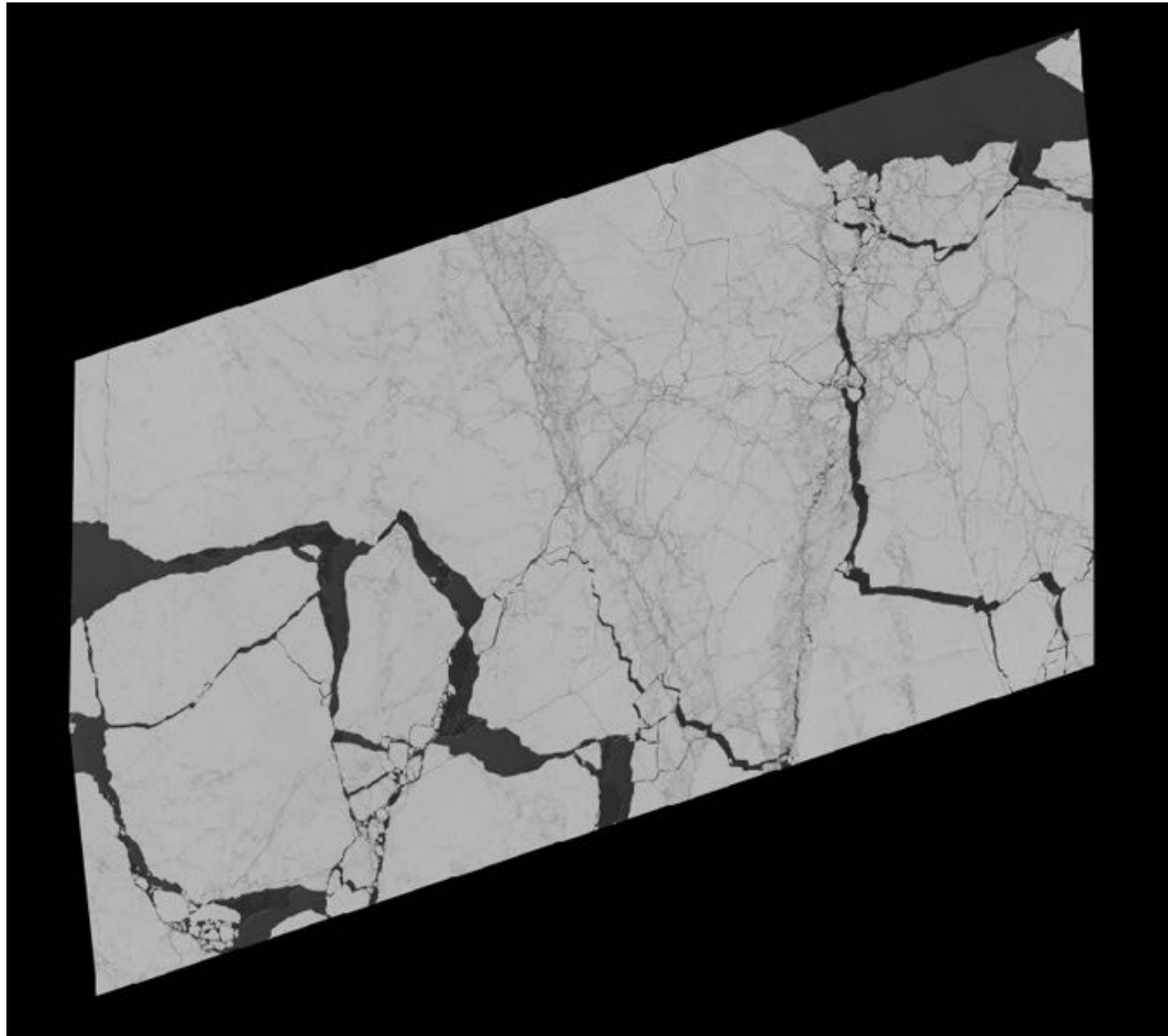
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Is there anything
dynamic here?

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Is there
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<http://www.wired.com/wiredscience/2009/07/seaicedata/>

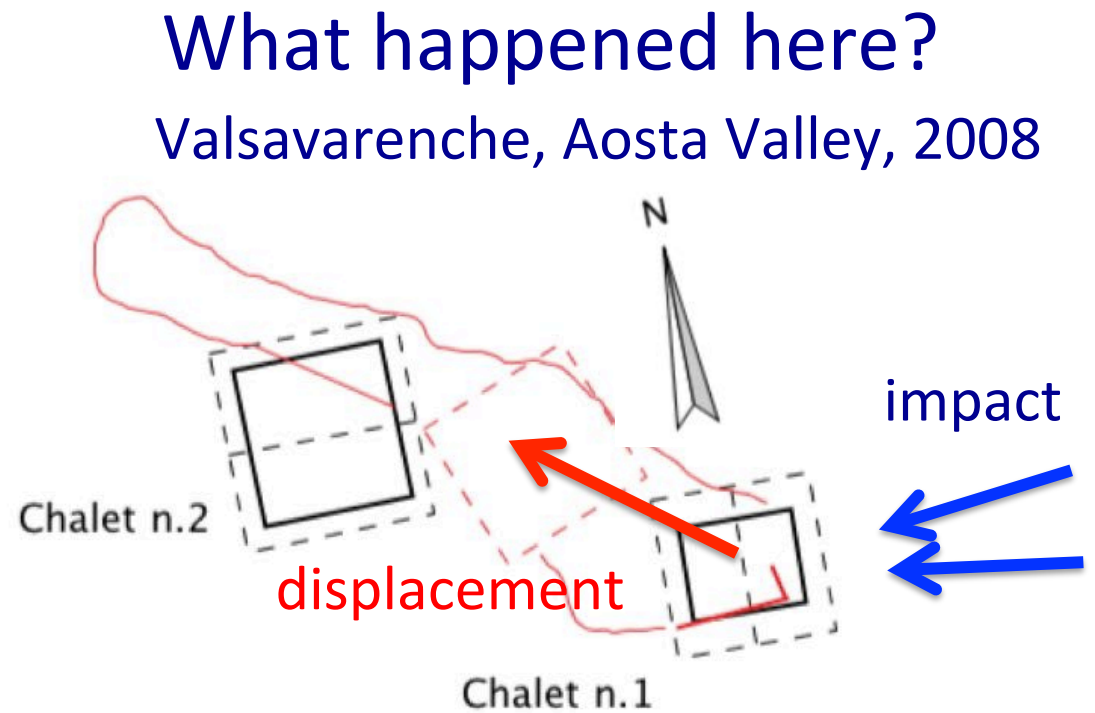
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Could anything dynamic happen here?



(b) Chalet n.1 before the event



(a) Chalet n.1 after the event



(b) view from south-east



(c) view from north

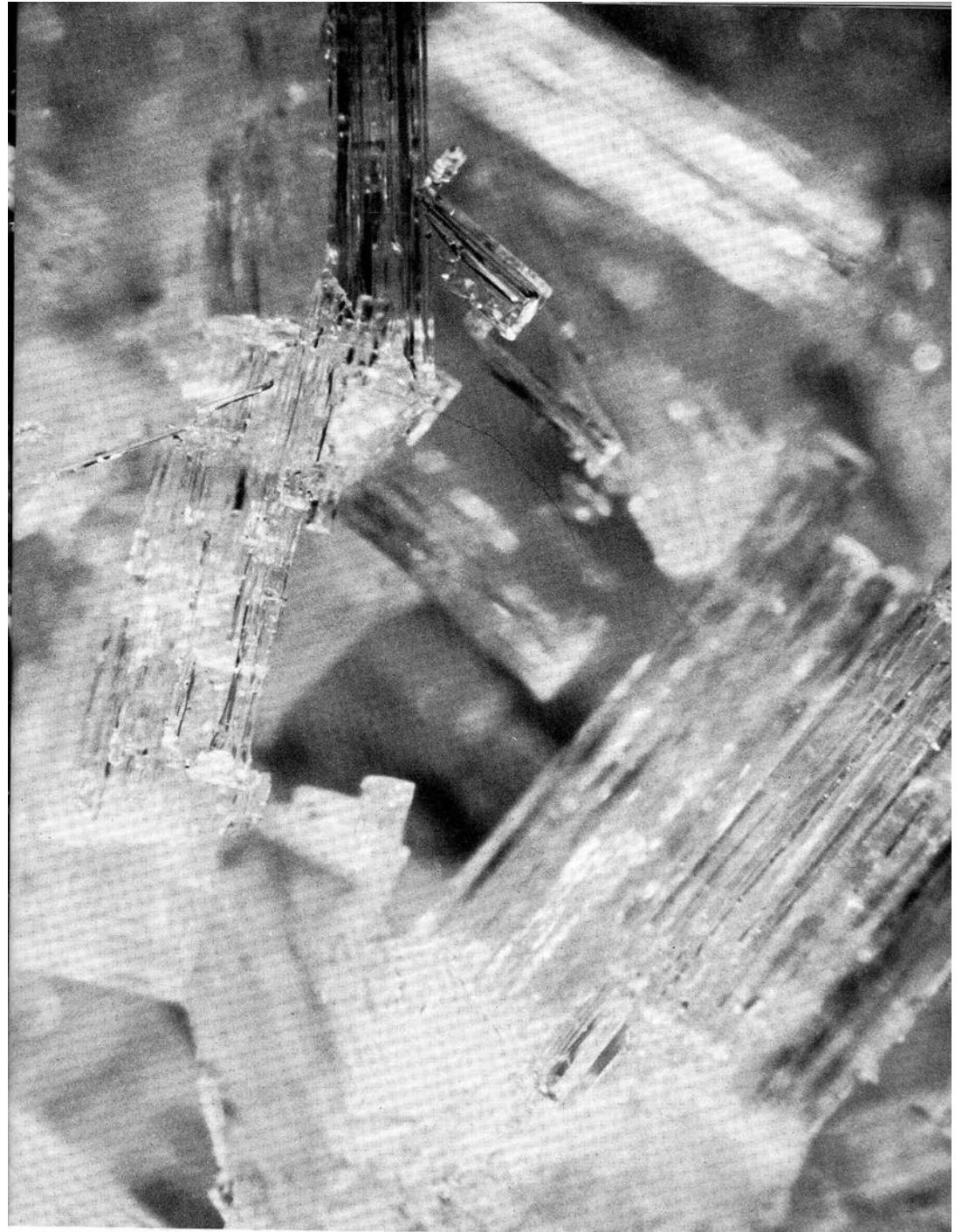
What is this?



Milford Road, New Zealand

What is this?

Is there anything
dynamic here?

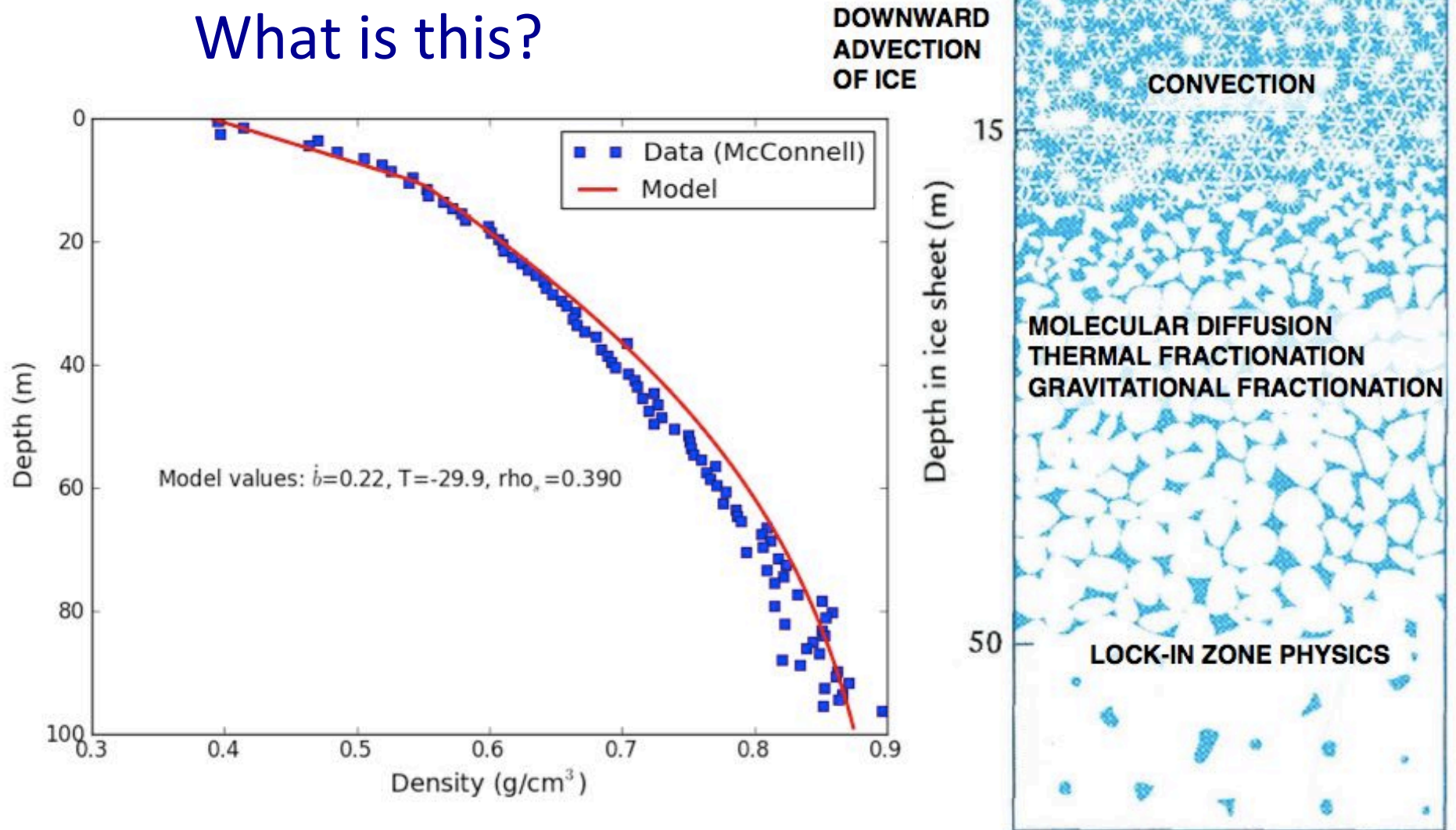


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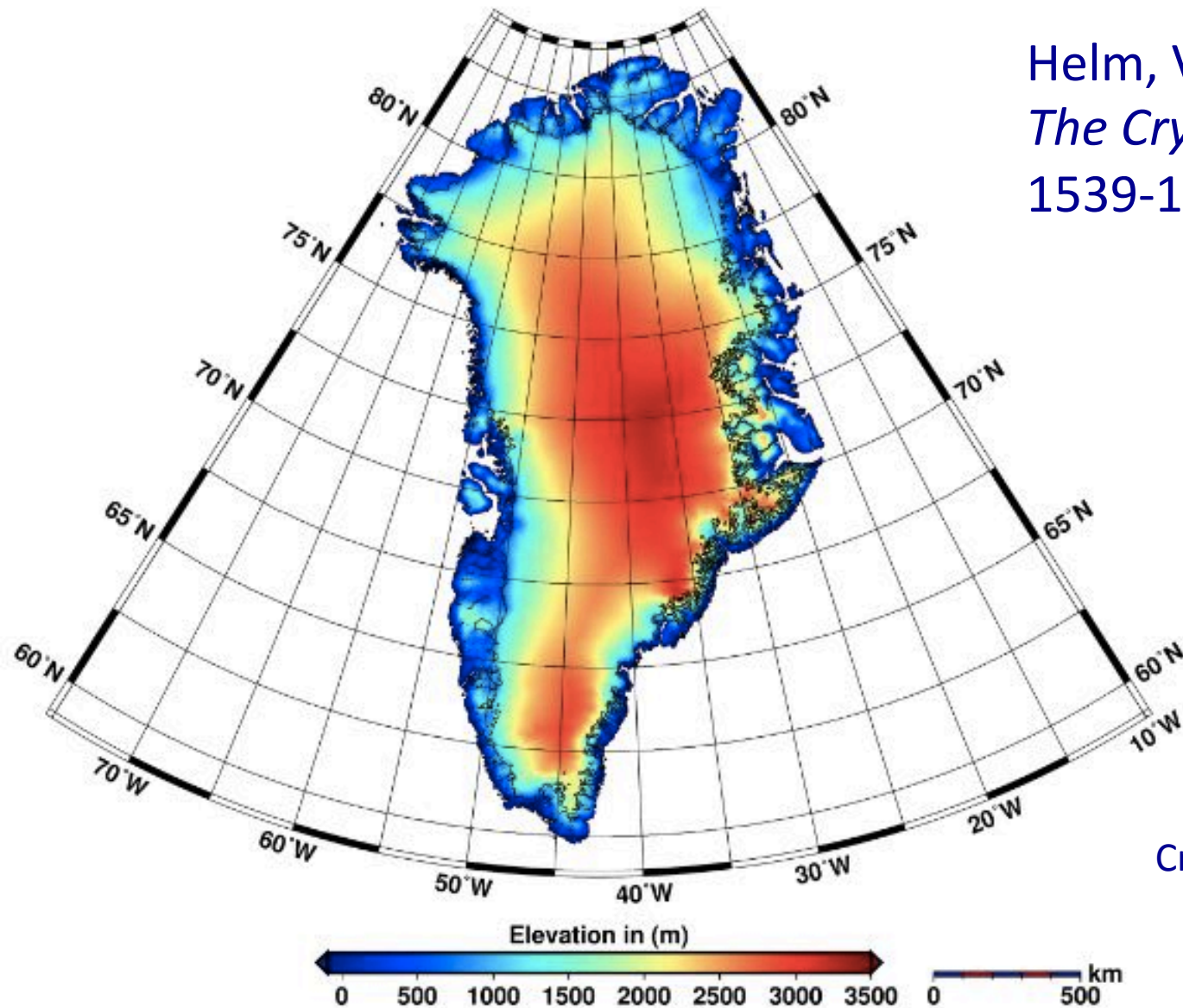


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Anything dynamic here?

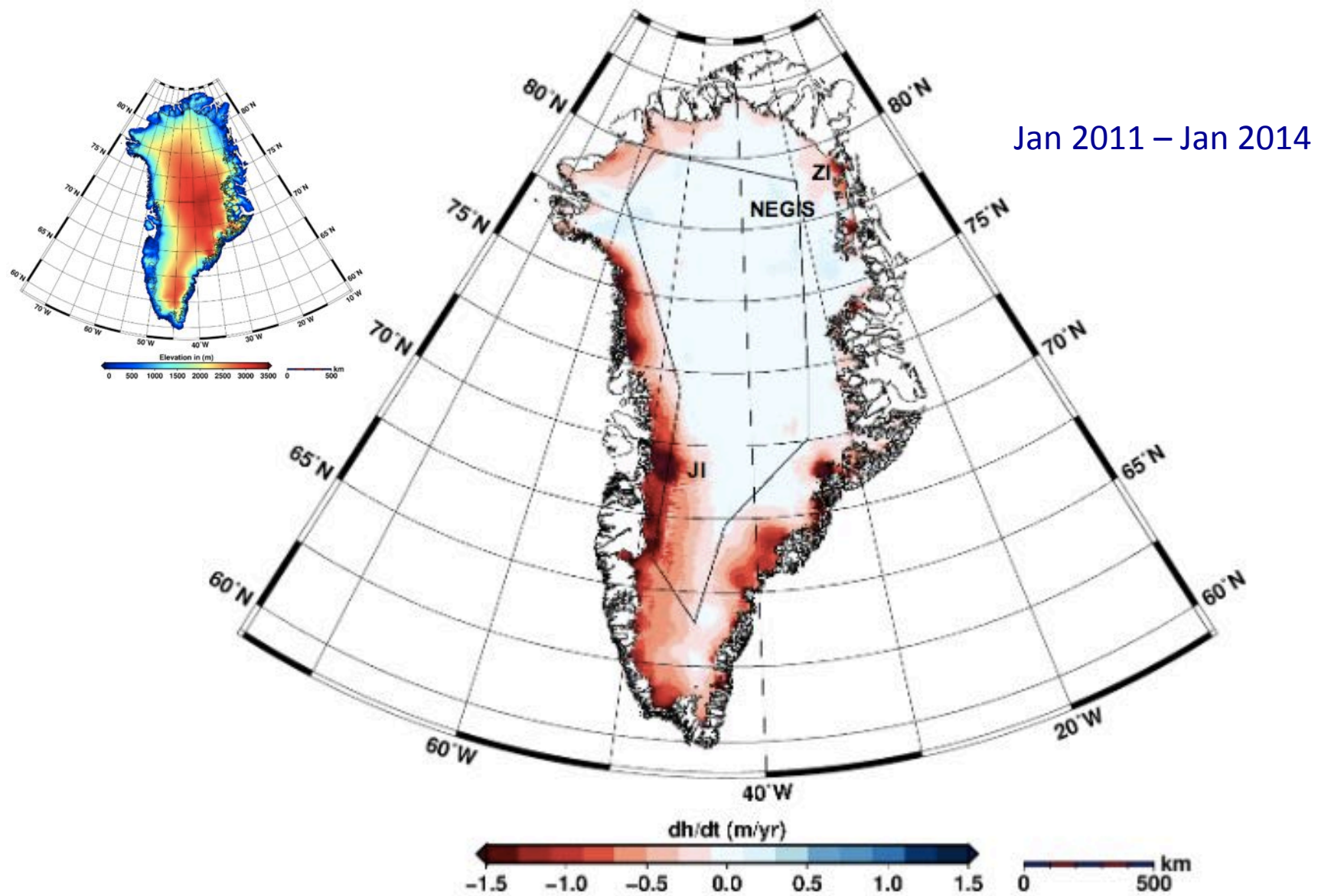
Anything dynamic here?



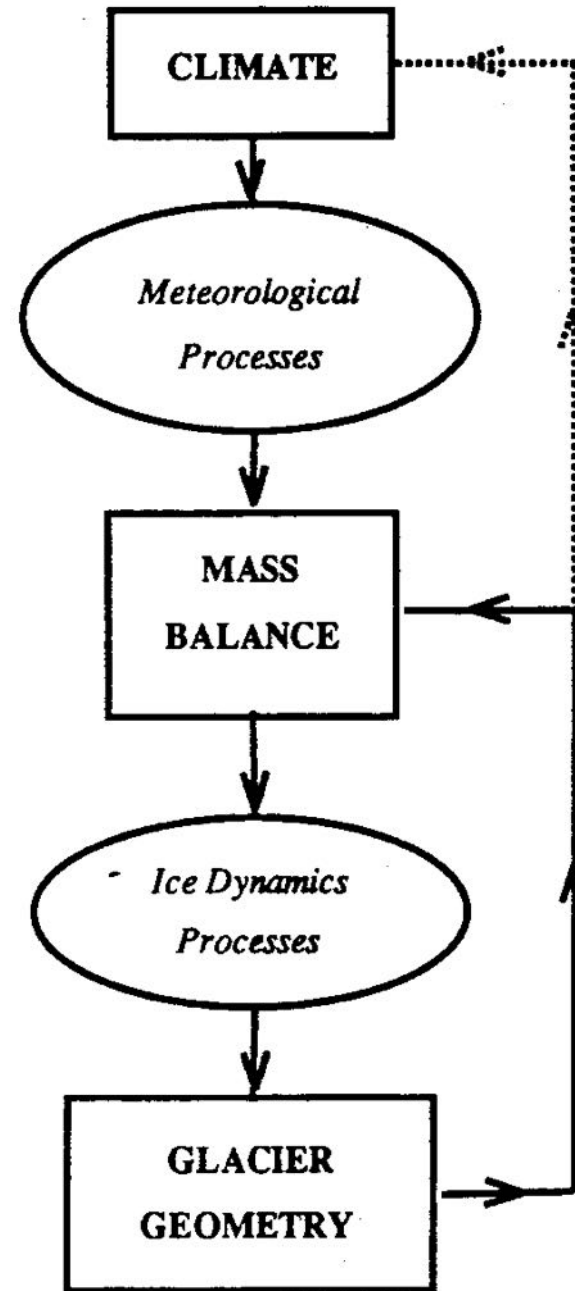
Helm, V. et al. 2014.
The Cryosphere 8,
1539-1559.

Cryosat-2

Anything dynamic here?

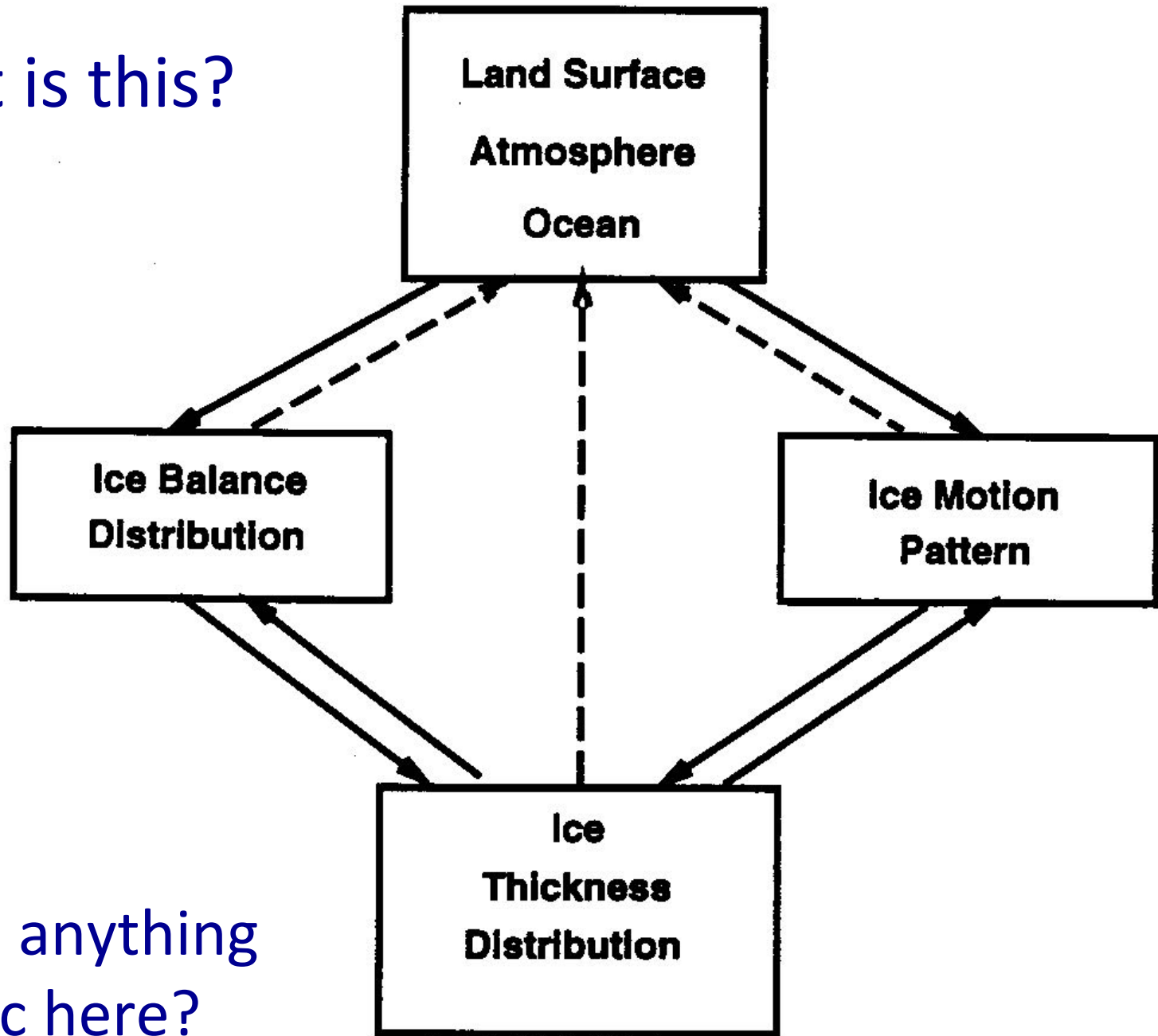


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Is there anything dynamic here?

What is this?



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