What if the ice block expedition 1959 happens in 2021?

You cannot blame it to climate change

Zhihao LIU

The expedition | questions | model | results | discussion

Background

- 3050 Kg cubic ice from glacier Svartisen
- 25 cm glasswool and iron container.
- on 22 February 1959, at 9:15 am, the expedition left Mo i Rana.
- only four litres of water had been shed until Marseille
- once the Sahara was traversed, 177 litres had melted away. On average 15 litres melted each day in the desert.
- arrived at Libreville on 21 March.
- lost only 336 kg along the way (11%)

Video source: https://www.youtube.com/watch?v=L9PMssvldaw

Questions | model | results | discussion

Can an energy balance model answer the questions?

The objectives of the experiment is to answer:

- What if the ice block expedition 1959 happens in 2020 and 2021 again?
- Are we going to have more or less melt loss?
- If there is more melting loss, can we blame it on global warming?
- What if they don't used glass wool?
- Did Radio Luxembourg underestimate the insulation materials or the ice itself?

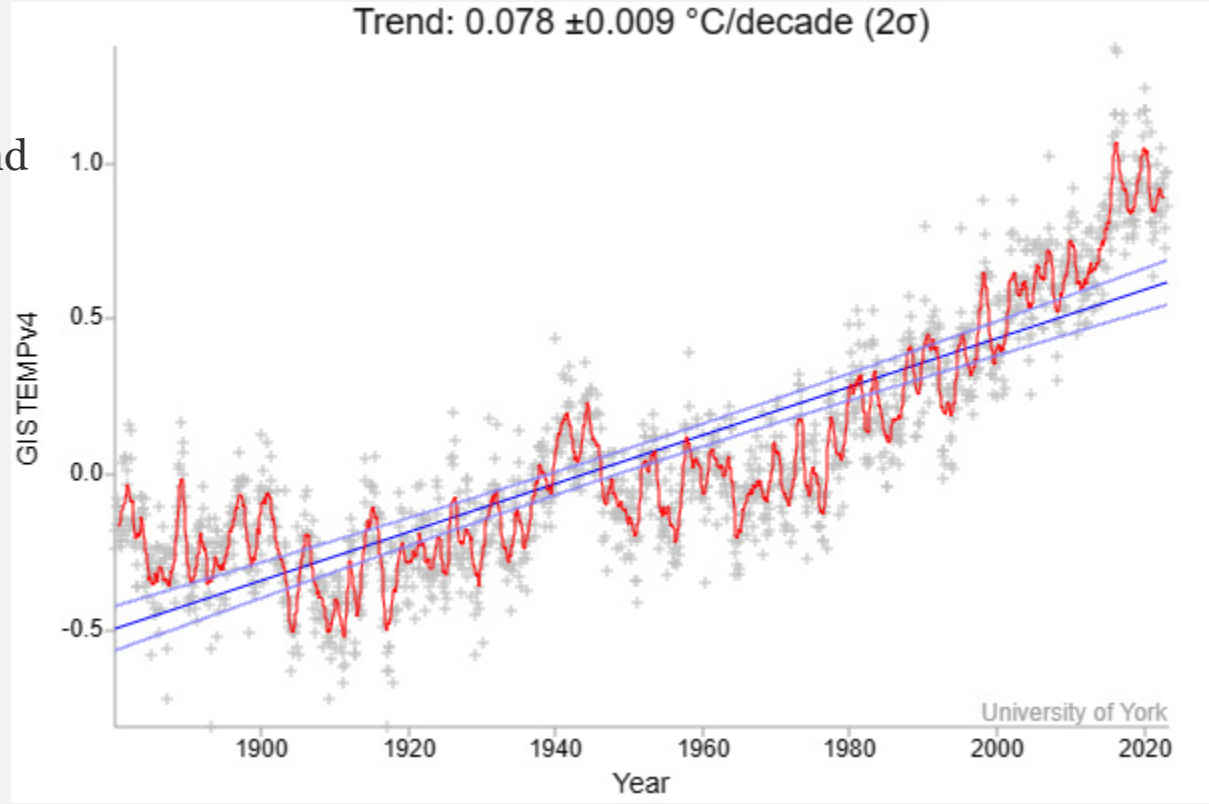


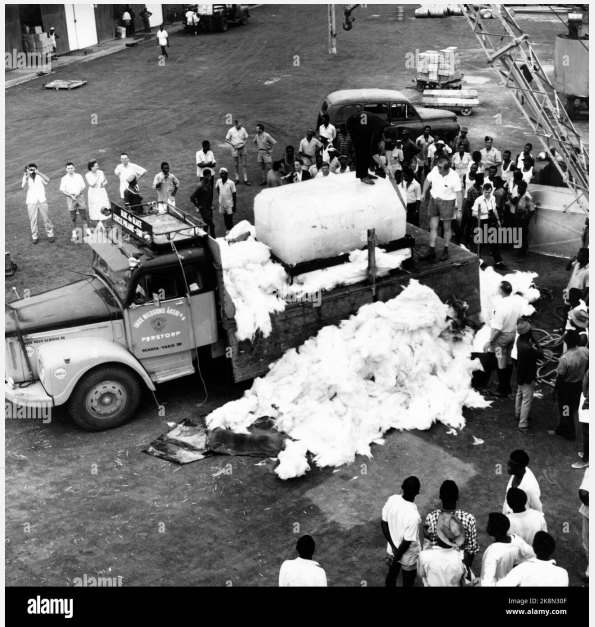
Fig 1. Global temperature time series

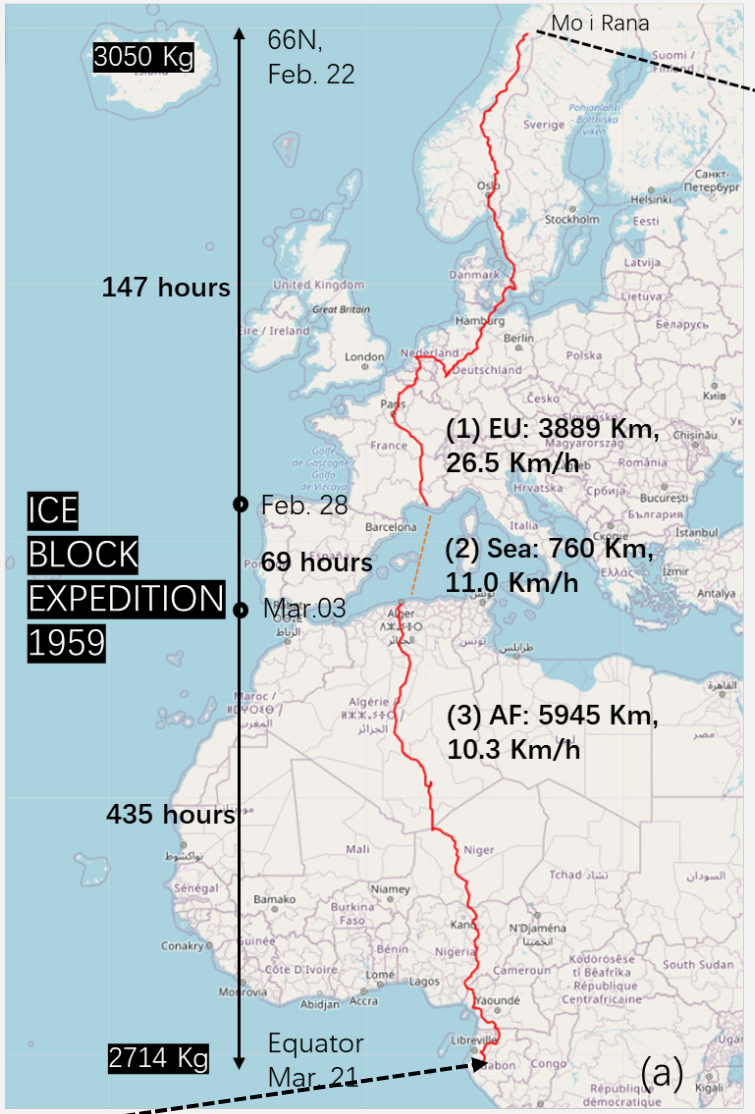
Data source: GISTEMPv4

Models | results | discussion

Energy balance model and heat diffusion model

Fig 2. From historical event to models





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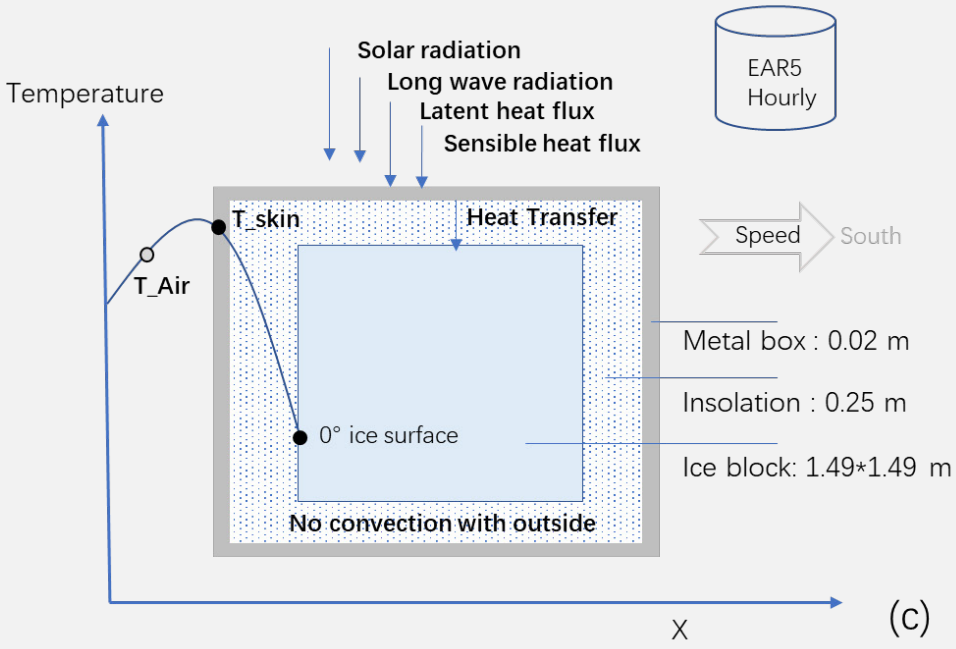


Models | results | discussion

Physics basis and materials

For the surface, the change of energy ∂_E over specific time ∂_t could be described by surface energy balance:

$$\frac{\partial_E}{\partial_t} = LW\downarrow + LW\uparrow + SW\downarrow + SW\uparrow + SF + LF + Q_{heatflux}$$

Net longwave radiation and shortwave radiation:

$$LW_{net} = L_{in} - (\varepsilon \cdot \sigma \cdot {T_s}^4 + (1-\varepsilon) \cdot L_{in})$$

$$SW_{net} = SW_{in}(1-\alpha)$$

Where L_{in} is the incoming long radiation, emissivity ε. Further, Stefan-Boltzmann constant $\sigma = 5.67 \times 10^{-8}\ \mathrm{Wm^{-2}K^{-4}}$, T_s is surface temperature in Kelvin. SW_{in} is the incoming short radiation, and α is albedo of the surface.

Sensible heat flux and latent heat flux is given by:

$$Q_{sen} = \rho_a \cdot c_{pa} \cdot A \cdot u \cdot (T_{air} - T_s)$$

$$Q_{lat} = -\rho_a \cdot L_v \cdot A \cdot u \cdot \frac{0.622 \cdot (e_s - e_{actual})}{P}$$

Heat flux in one-dimensional is given by Fourier's law:

$$q = -k \cdot \frac{dT}{dx}$$

Or, heat flux could be derived from Fick's second law (heat equation) in 3-D:

$$\left(\frac{\partial^2 T}{\partial_{x^2}} + \frac{\partial^2 T}{\partial_{y^2}} + \frac{\partial^2 T}{\partial_{z^2}}\right) + \frac{q}{k} = \frac{\rho \cdot c_p}{k} \cdot \frac{\partial_T}{\partial_t}$$

Where T is temperature, t is time, x, y, z is the length of dimensions, and k is heat conductivity, ρ is density, c is specific heat capacity, q is the heat generation flux.

Table 1. *Characteristics of materials.*

Layer	Properties	density [Kg/m3]	heat capacity [J/(KgK)]	albedo	emissivity	Heat conductivity [W/(mK)]	Diffusivity [mm2/s]	Thickness [m]
Ice block	Ice	917	2108	0.5	0.97	2.3	1.19	-
Ice block	Water	1000	4182	-	0.97	-	-	-
Box	Aluminum	2700	890	0.61	0.25	237	-	0.02
Box	Galvanized steel	7800	470	0.61	0.04	52	-	0.02
Box	Pine wood	510	2301	0.15	0.90	0.11	-	0.02
Insulation	Glass wool	20	840	-	-	0.04	1.79	0.25
Insulation	Clay-Sawdust (10%)	1648	838	-	-	0.63	0.45	0.25
Insulation	Sawdust	210	900	-	-	0.08	0.42	0.25

Results | discussion

Forcing data and surface temperature (1959)

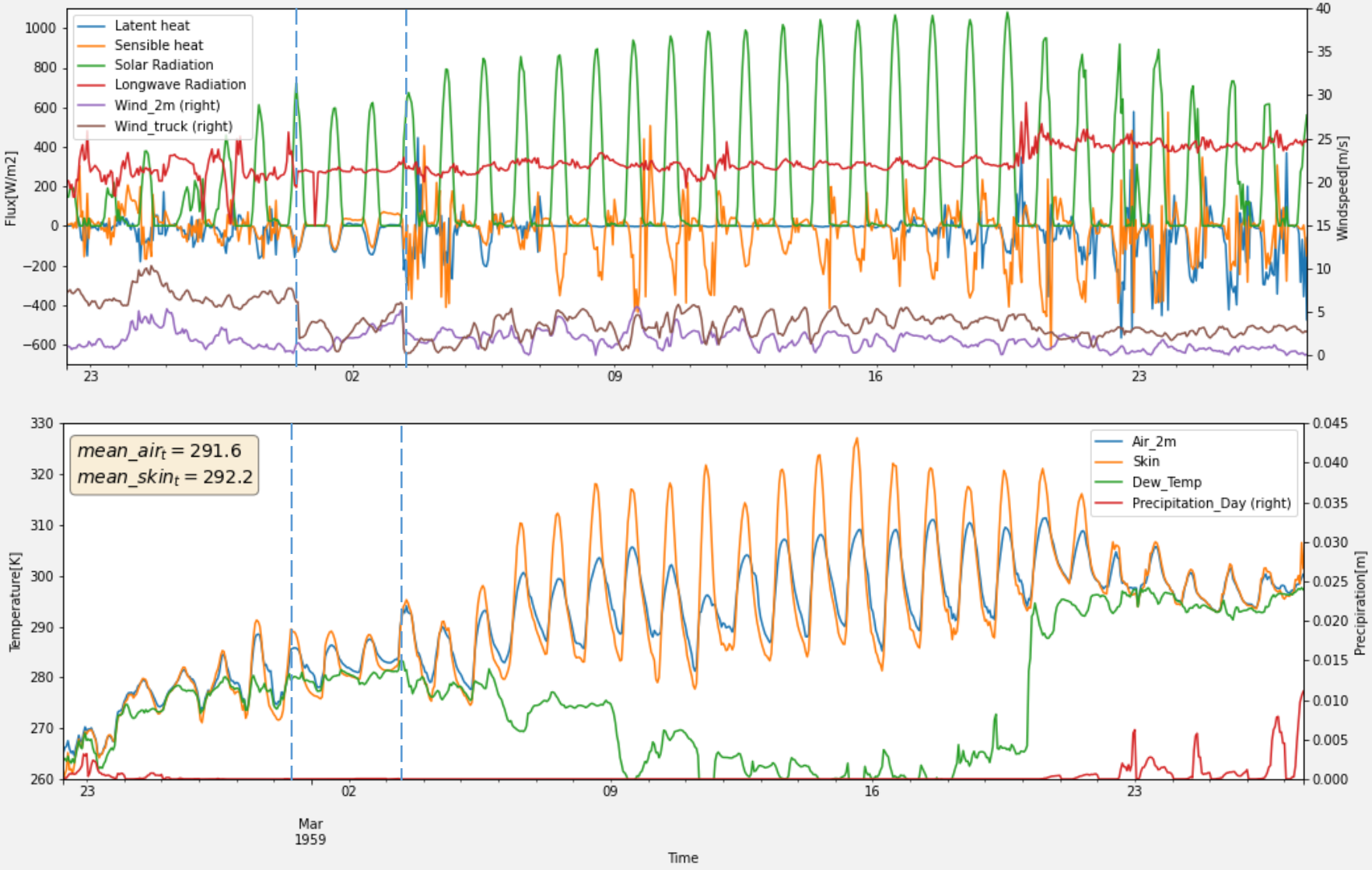
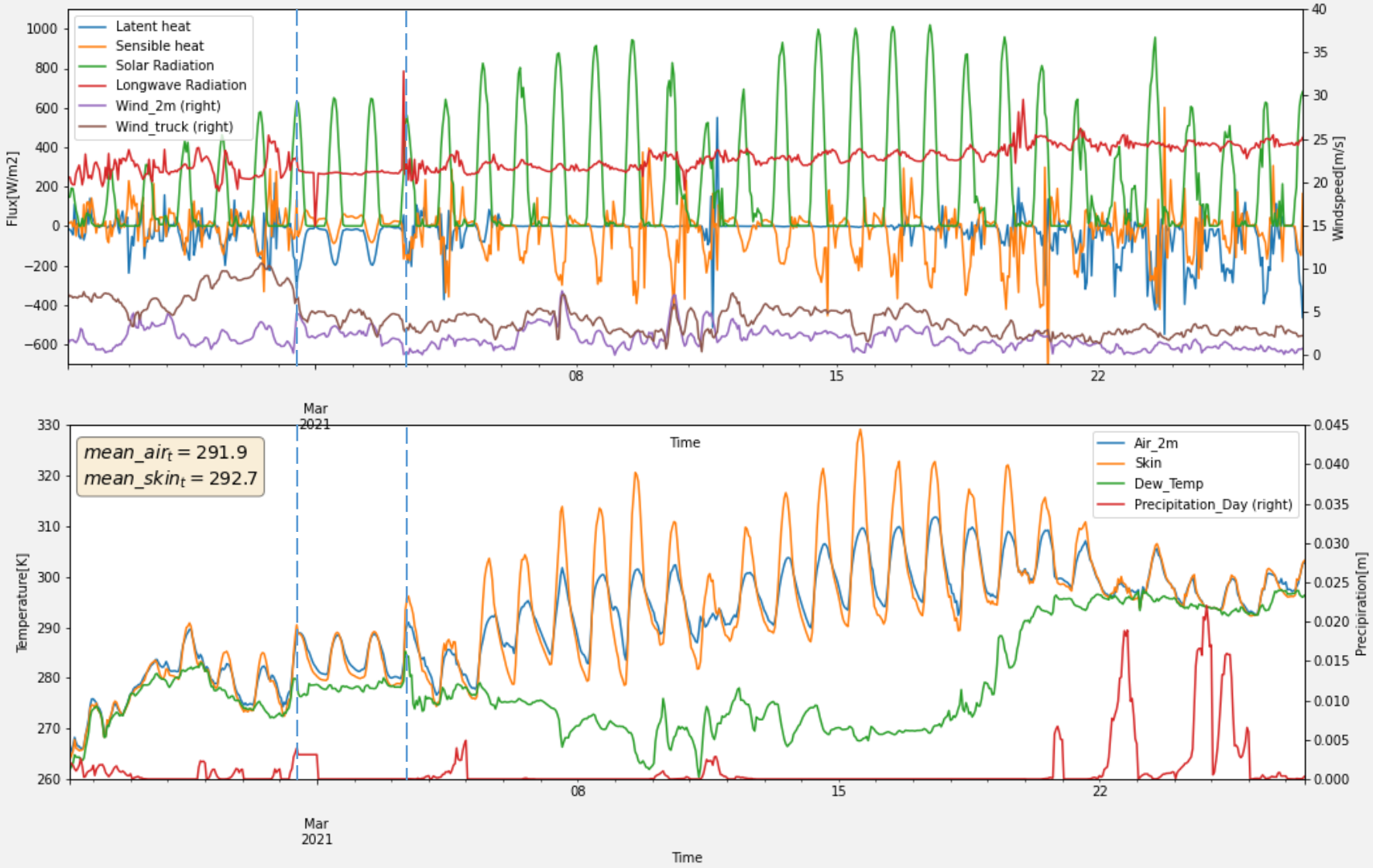


Fig 3. Forcing data from ERA5 Land (1959)

Results | discussion

Forcing data and surface temperature (2021)



- Air temperature 0.3 C higher
- Heavey wind in 2021.
- Increase humidity and less solar radiation.
- Skin temperature 0.5 C higher

Fig 4. Forcing data from ERA5 Land (2021)

Results | discussion

1959 < 2021 : if there is bare ice

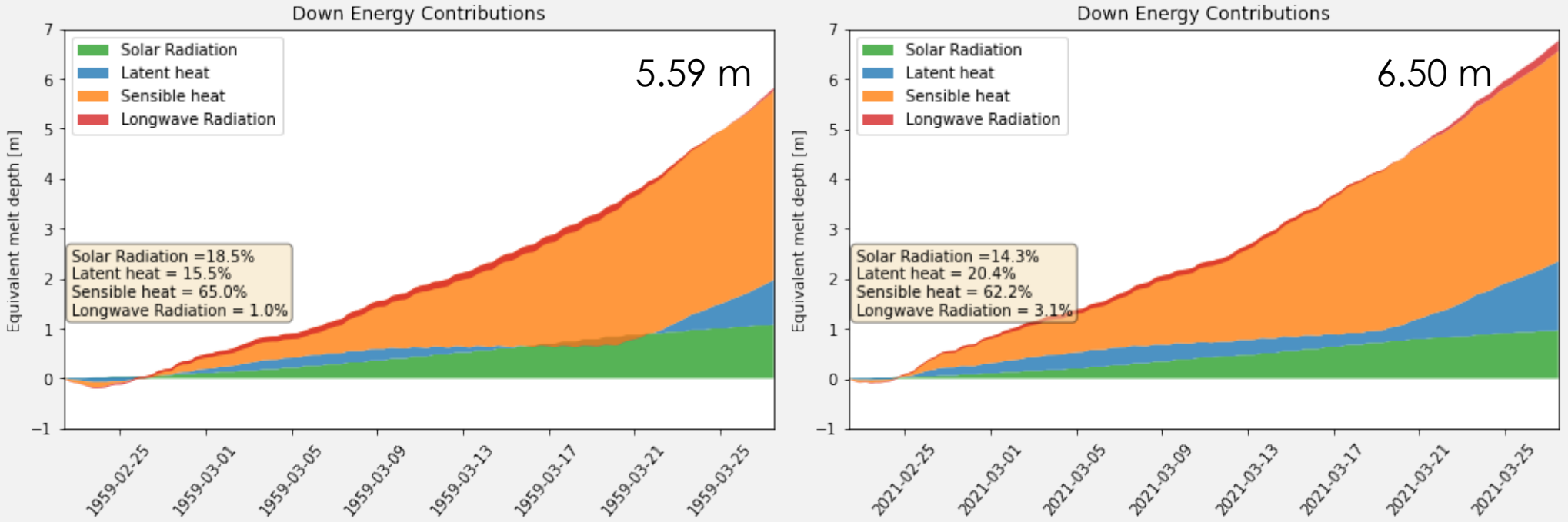


Fig 5. Bare Ice Senarioes (1959 vs 2021)

Understanding from comparison:

- This is the bare surface. The ice surface does not behave like a soil, becasue its always 0 celcius degree and water is alway available.
- Sensible heat flux donimates (air temperature and wind speed)

Results | discussion

2020 < 2021 < 1959 : if there is aluminum container and glass wool

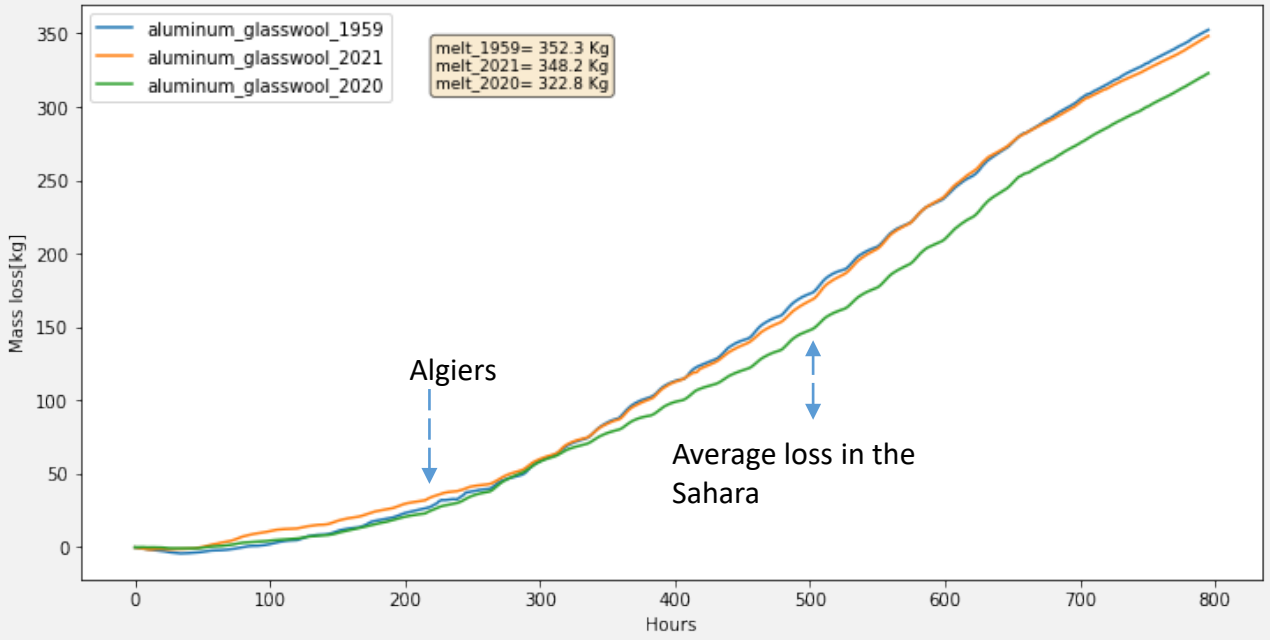
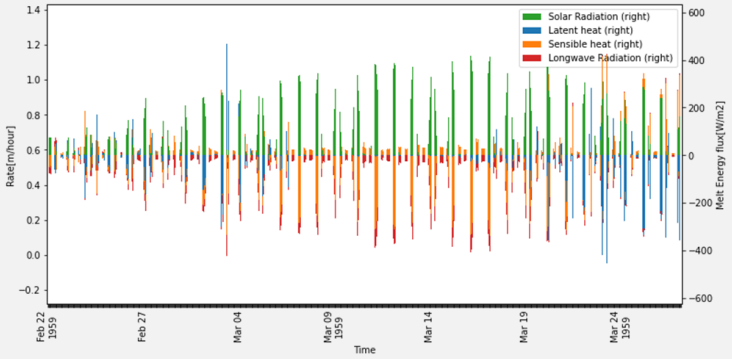
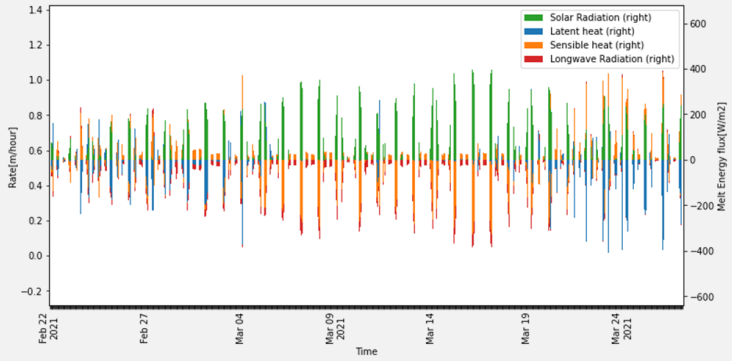


Fig 6. Nomal Senarioes (1959 vs 2020 vs 2021)

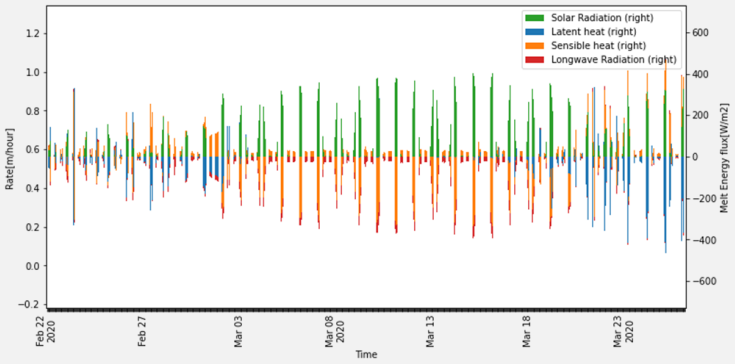
1959



2021



2020



Results | discussion

Wooden < Steel < Aluminum: which cover is the coolest

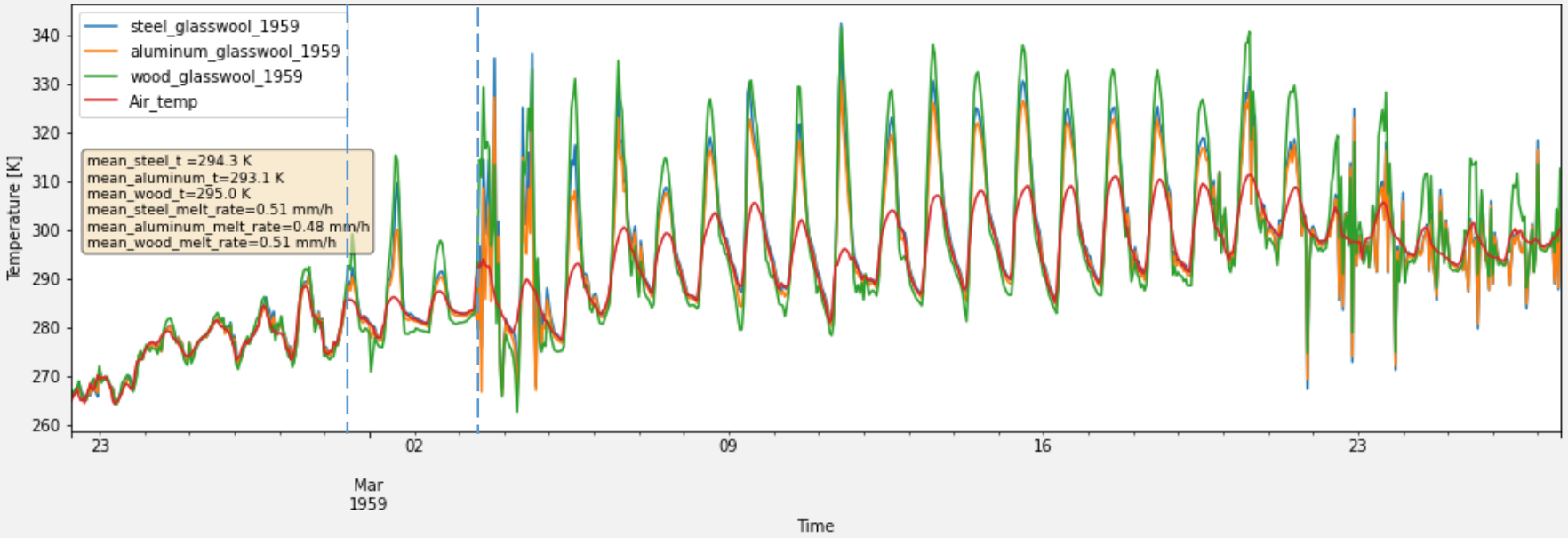


Fig 7. The surface temperature of container

Results | discussion

Saw dust : the alternative to glass wool

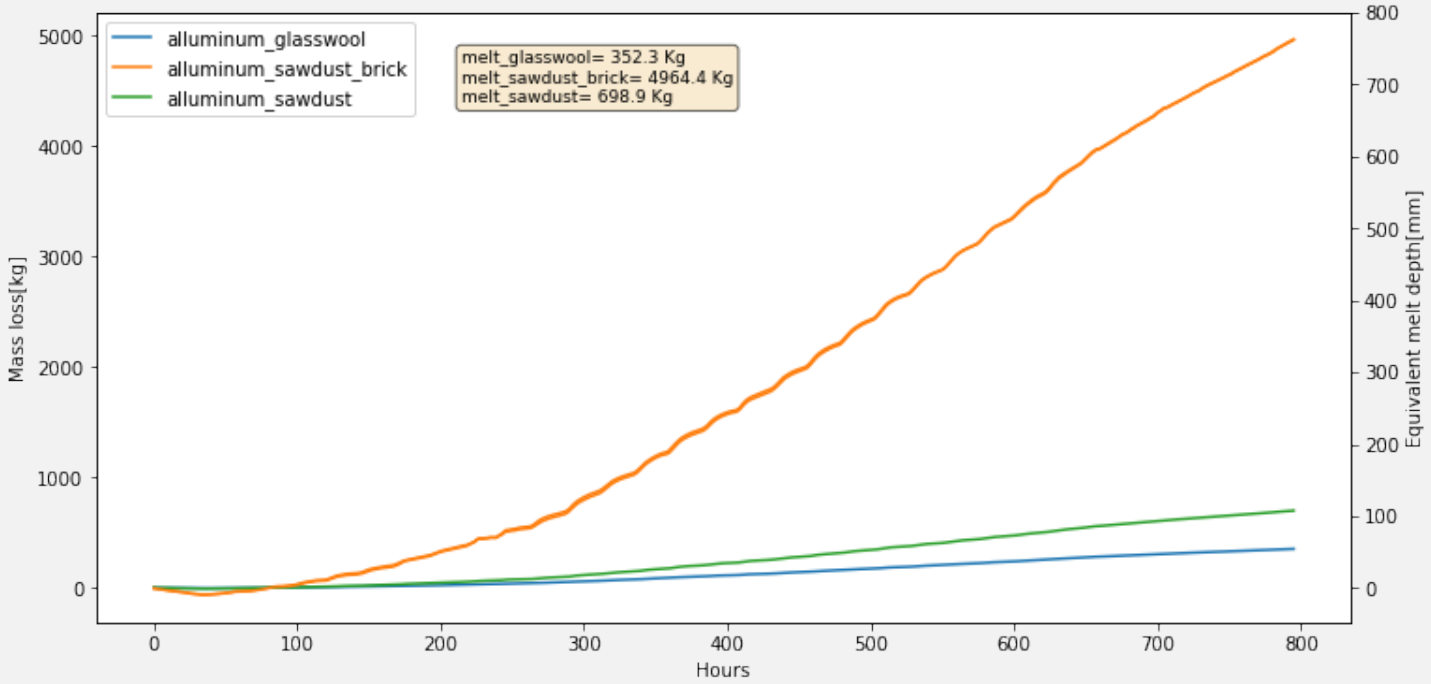
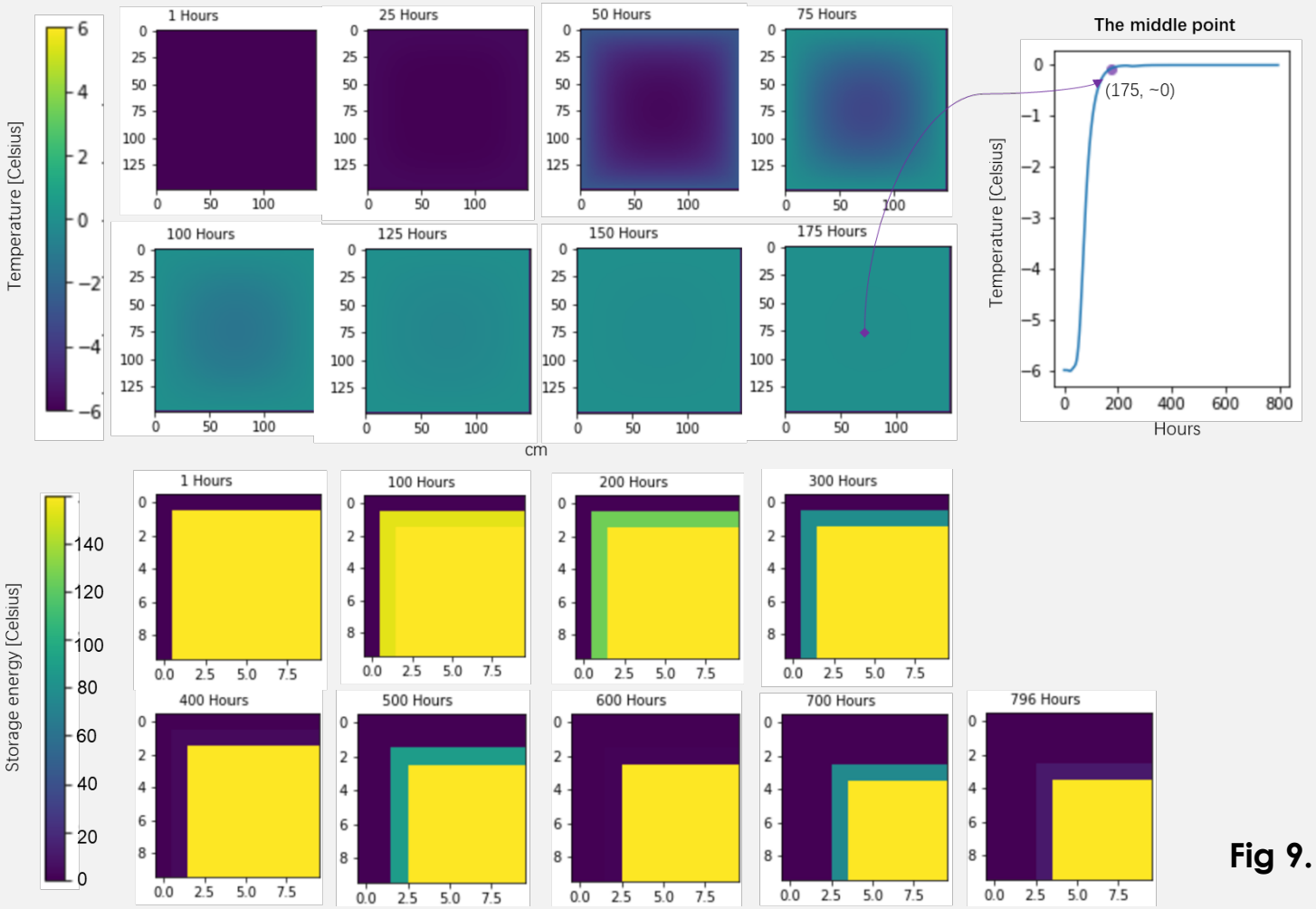


Fig 8. The mass loss of different insulation materials

Results | discussion

Does the core of ice block still below 0 degree Celsius ?



The truth of the cold content:
Fusion heat of ice = 333.55 J/g

Fig 9. The heat distribution of the ice block

Discussion

Not just the ice block expedition…

While we set a baseline using the 1959 ice block expedition. The melt loss of transporting ice is not projected to be greater than 1959 if we do another expedition in 2021. Additionally, the simulations do not support attributing the concern to global warming because the ice is covered.

Not just the ice block expedition…

In the 19th-century, A million tons of ice was shipped from Norway each year during the golden age of ice trade. As the primary concerns of the business is melting lost, so we can call it ‘melting markets’.

By this experiment, this business has a solid physical basis.