# A global circulation model for the asteroid impact simulations

Hakan Sert, Orkun Temel, Cem Berk Senel,
Ozgur Karatekin

ROYAL OBSERVATORY
of BELGIUM

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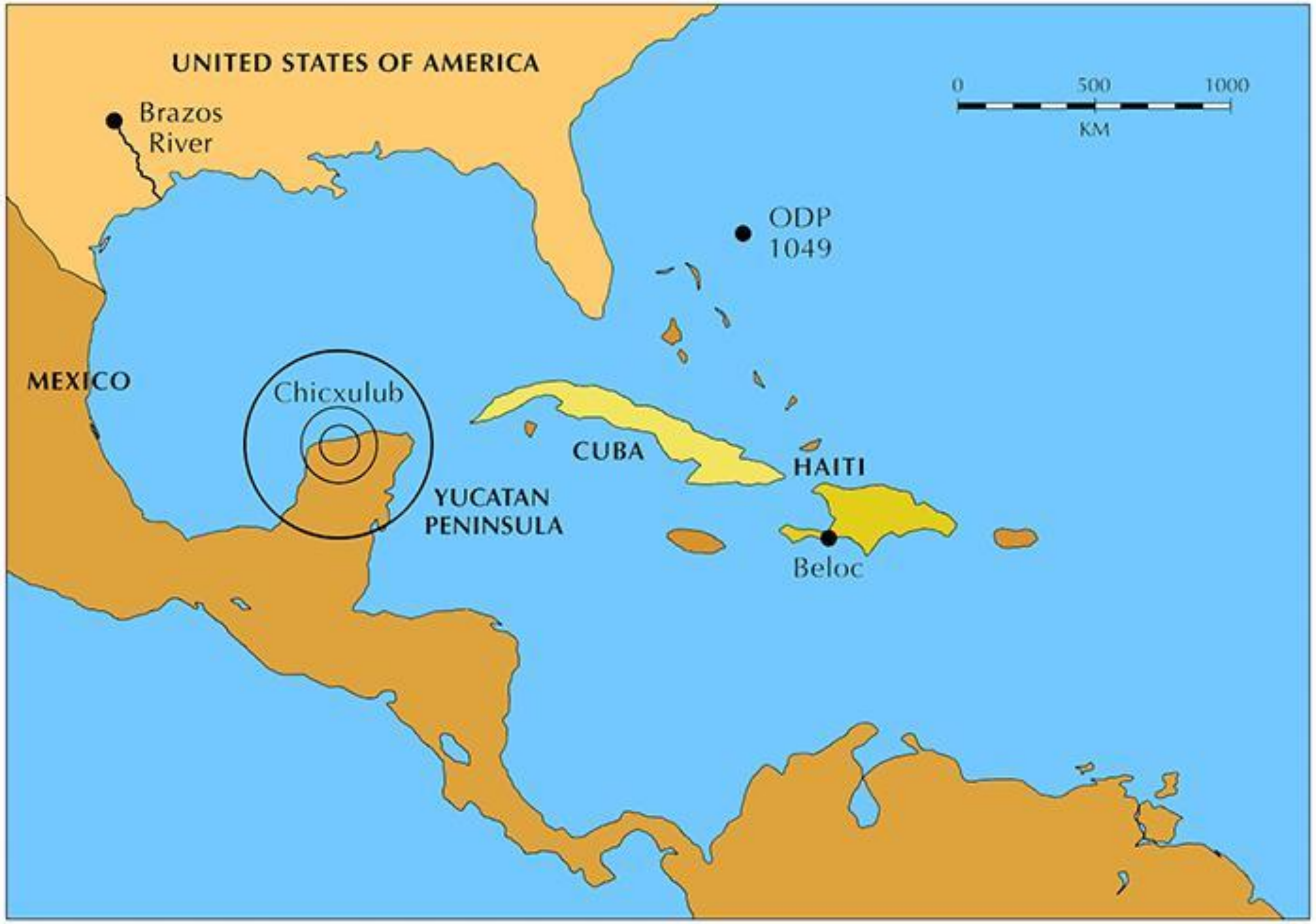
# Summary

- planetWRF model [1], a multiscale atmospheric model being used for Mars, Titan and Venus, is modified for Earth/Paleoclimate simulations
- The model is applied to model the atmospheric response of the Cretaceous–Paleogene (K–Pg) extinction event [2] which took place 66 million years ago and resulted in the mass extinction of various animal and plant species.
- The radiation parameterization scheme of the planetWRF model is modified to include the effect of various climate-active aerosols and gases released after the impact event.
- The atmospheric model is coupled with a 1D mixed layer model [3], coupling with a 3D ocean model [4] is still under development.

[1] Richardson, M. I., + JGR: Planets, 2007. [2] Schulte, P.+, Science, 2010. [3] Pollard, R. T.+, Geophys. Fluid. Dyn., 1973
[4] CY Lee and S. S. Chen, J. Atmos. Sci., 2012




Location of the Chicxulub impact crater.

http://craterexplorer.ca/chicxulub-impact-structure/

According to hydrocode simulations performed by Pierazzo et al. [1], the amount of climatically active gases released in to the atmospheres:

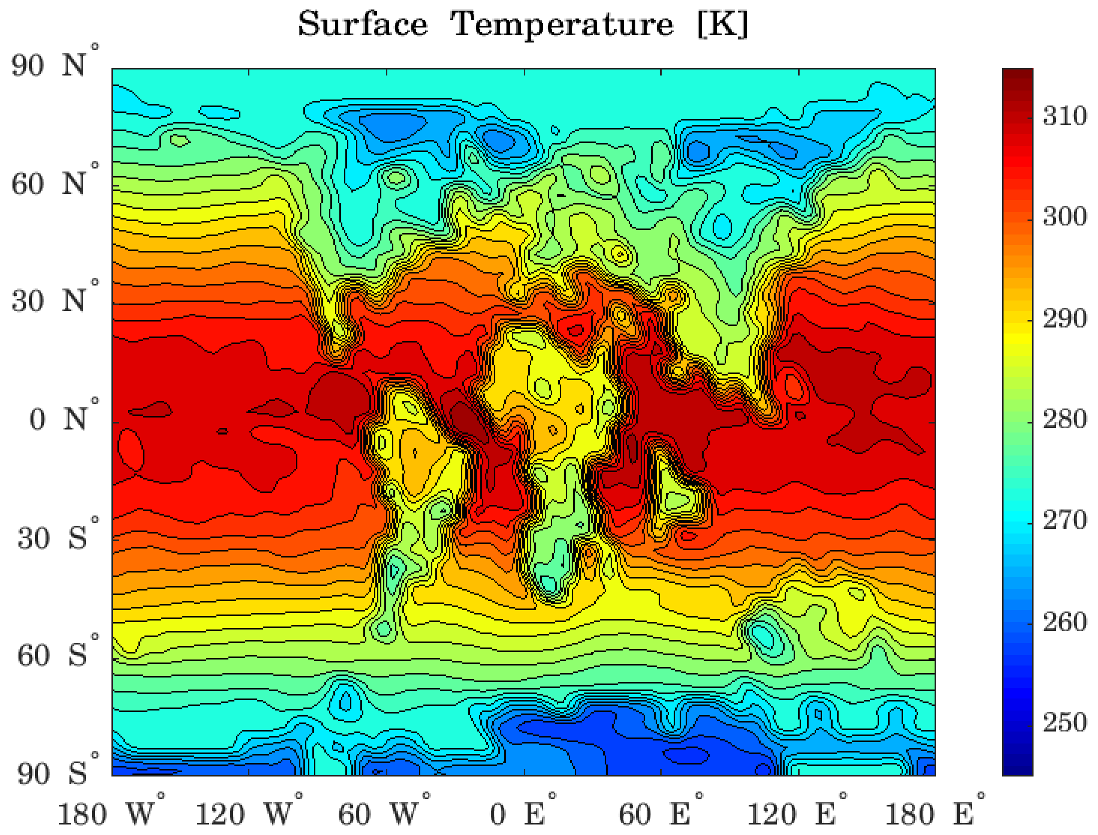
- 350-3500 Gt of carbon dioxide
- 40-560 Gt of sulfur
- 200-1400 Gt of water vapor

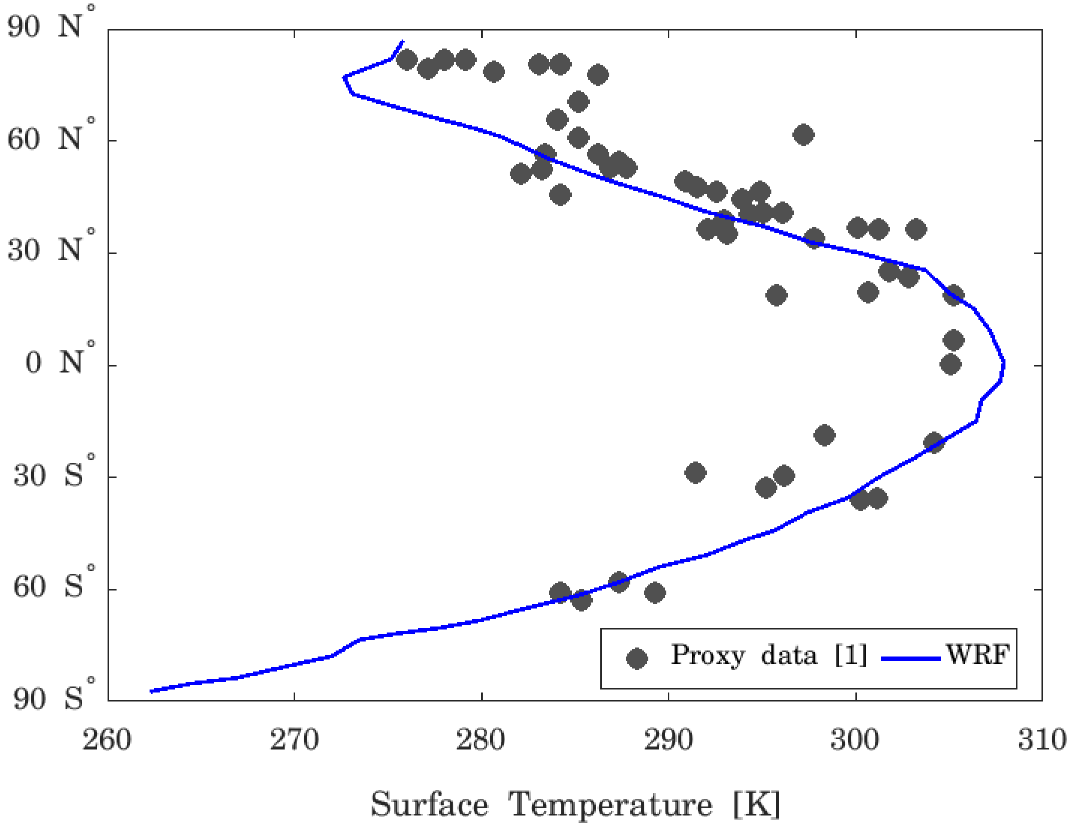
Vertical distribution of injections are prescribed according to Toon et al. [2]

[1] E. Pierazzo et al., J. Geophys. Res. (1998).
[2] Toon, O. B., et al. Atmospheric Chemistry and Physics 16.20 (2016): 13185-13212.

# planetWRF – Earth/Paleoclimate simulations

GCM simulations are perfomed using a modified version of planetWRF (a multiscale – from global scale to microscale – atmospheric model being used and developed at the Royal Observatory of Belgium.

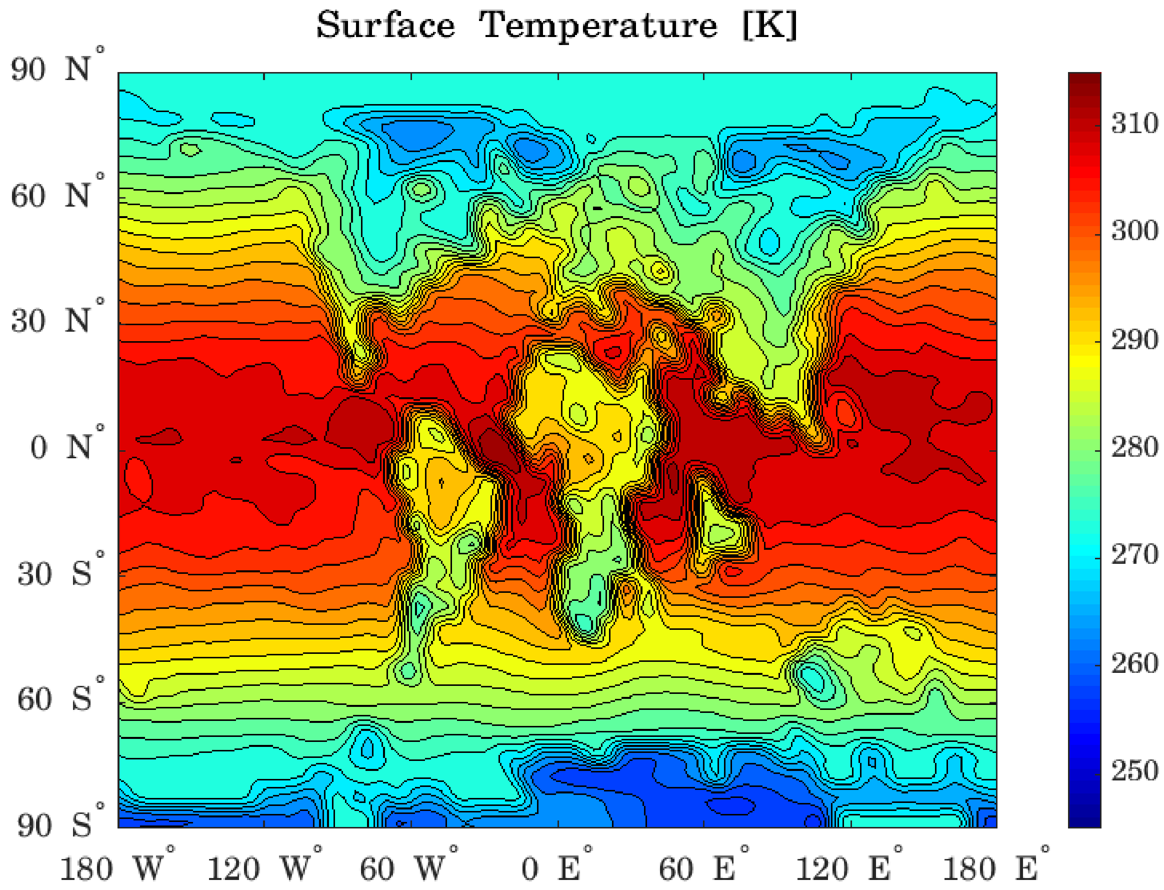


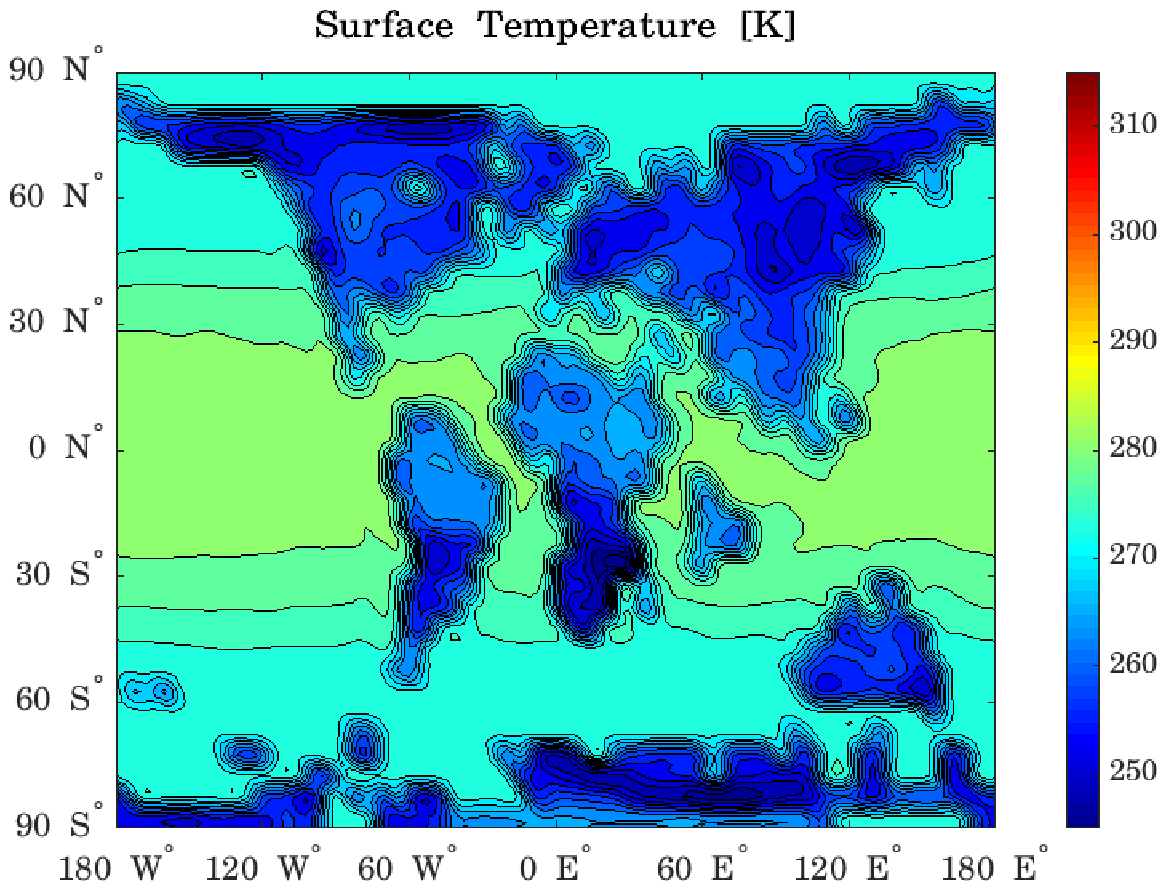




[1] Upchurch Jr+, Geology 43, no. 8 (2015): 683-686.

# Surface temperature – before/after 1 year the impact event

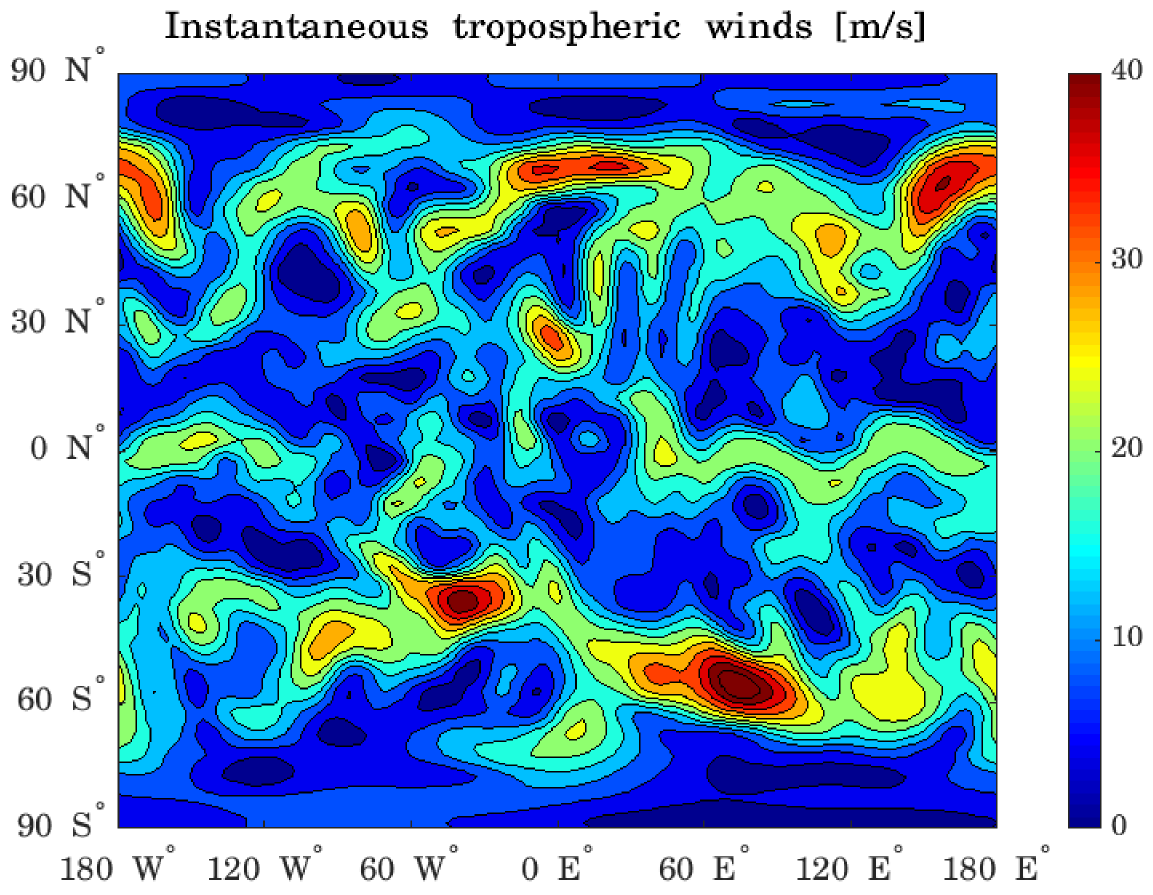
Sulfur aerosols blocks the sunlight and reduces the surface temperature after the impact event. As a result of the thermal inertia difference between ocean and land, a strong surface temperature gradient remains after the impact.

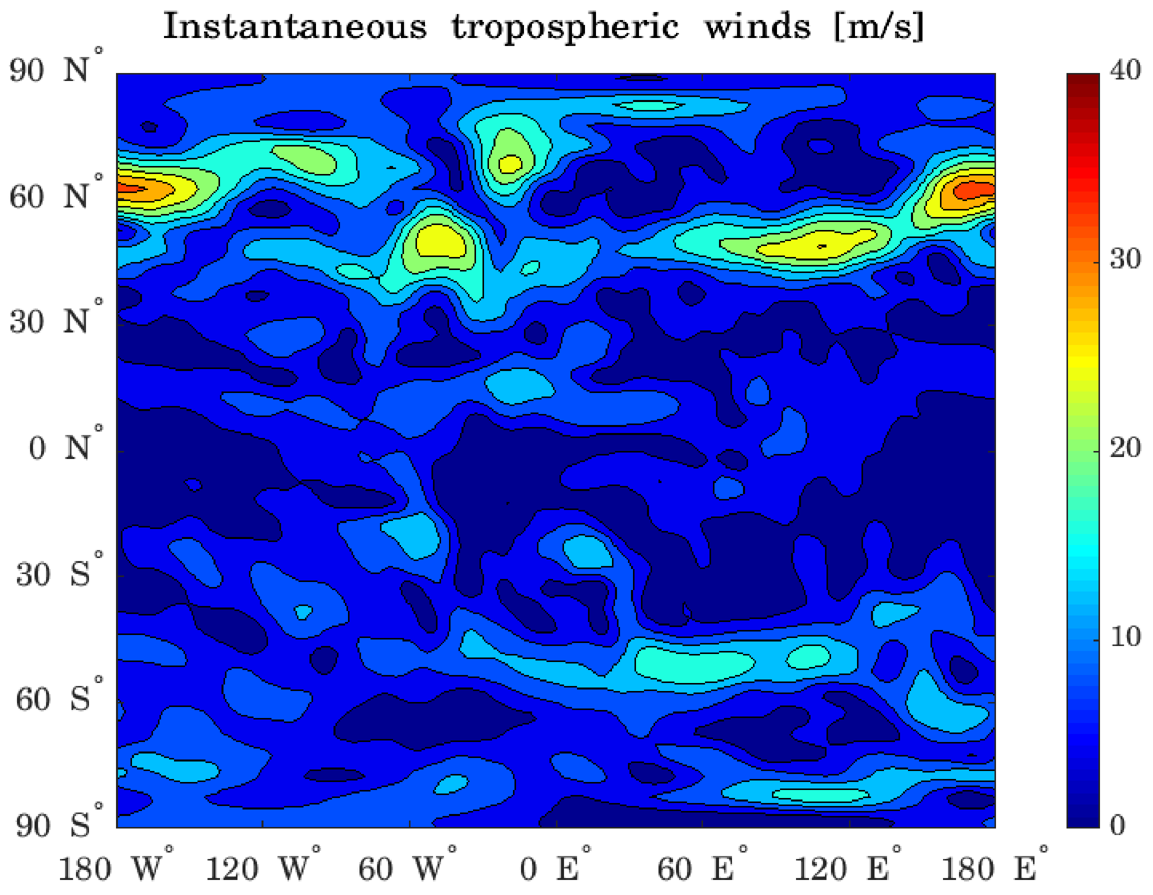


# Tropospheric winds – before/after 1 year the impact event

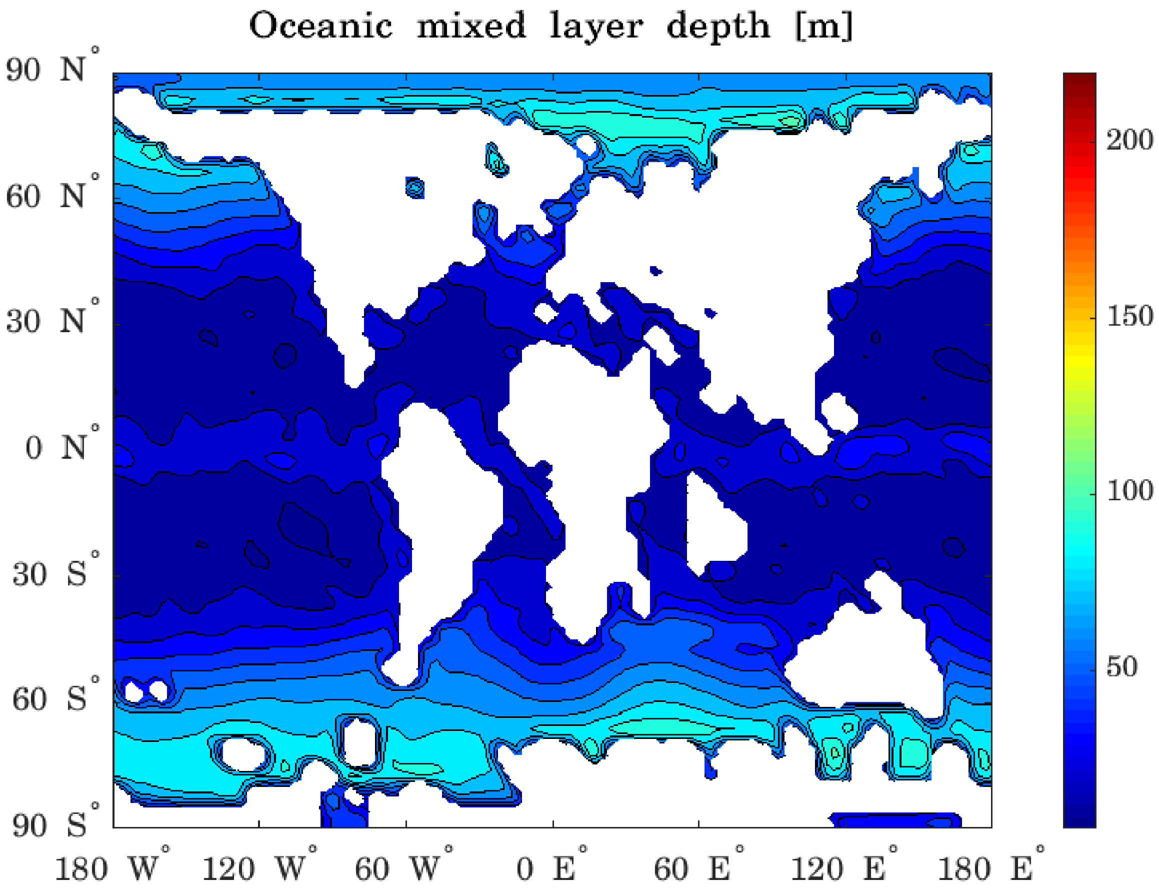
Despite the ocean-land temperature difference, temperature gradients weaken in the troposphere and it leads to weaker zonal and meridional transport.

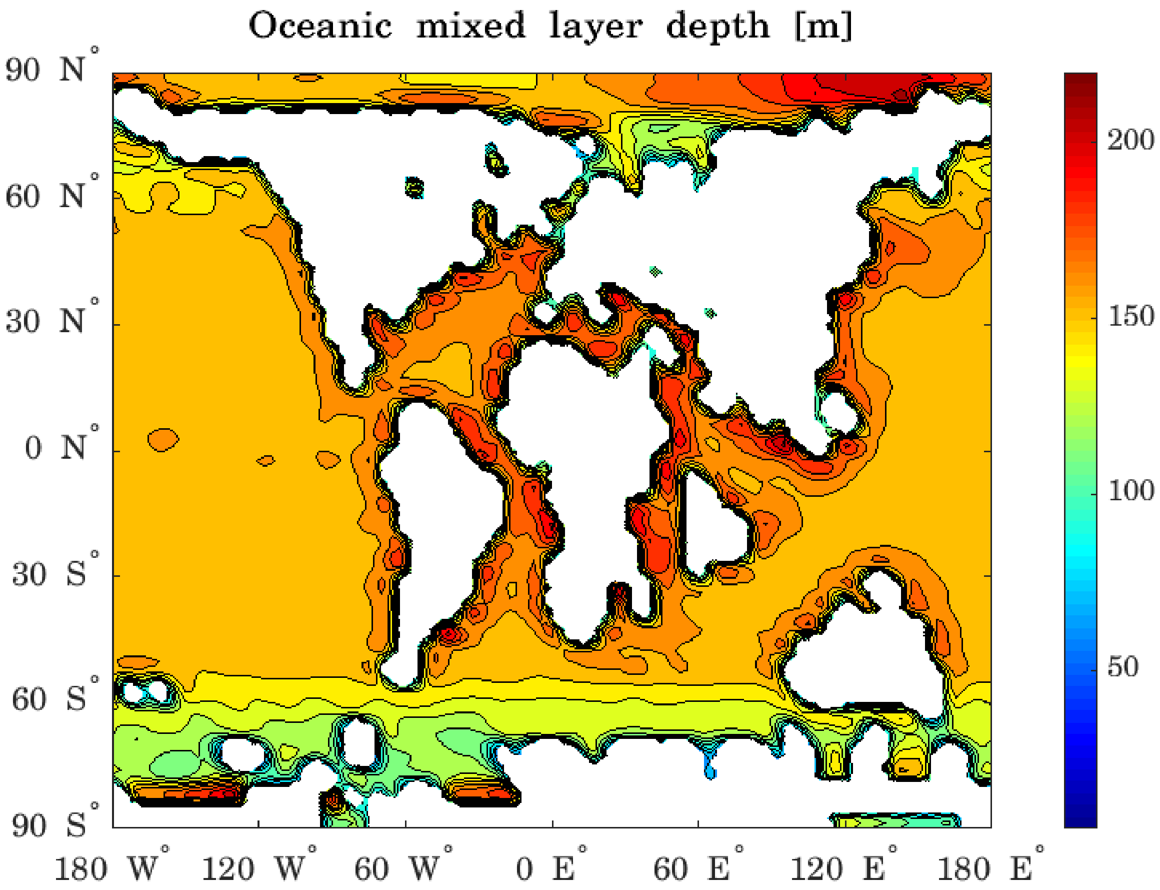


# Oceanic mixed layer depth – before/after 1 year the impact event

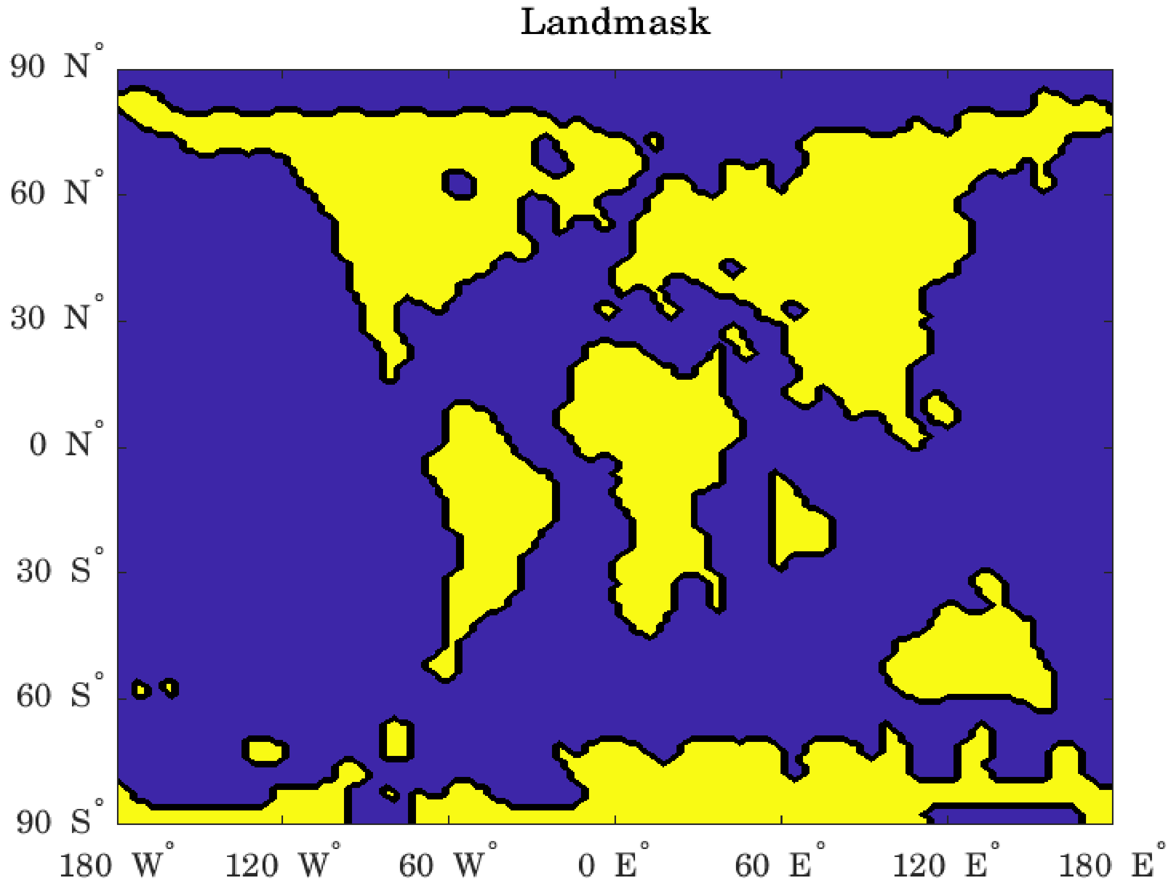
However, the near-surface meteorology is driven by strong temperature differences, leading to constant sea breeze conditions during the impact winter. High near surface winds deepens the oceanic mixed layer after the impact.

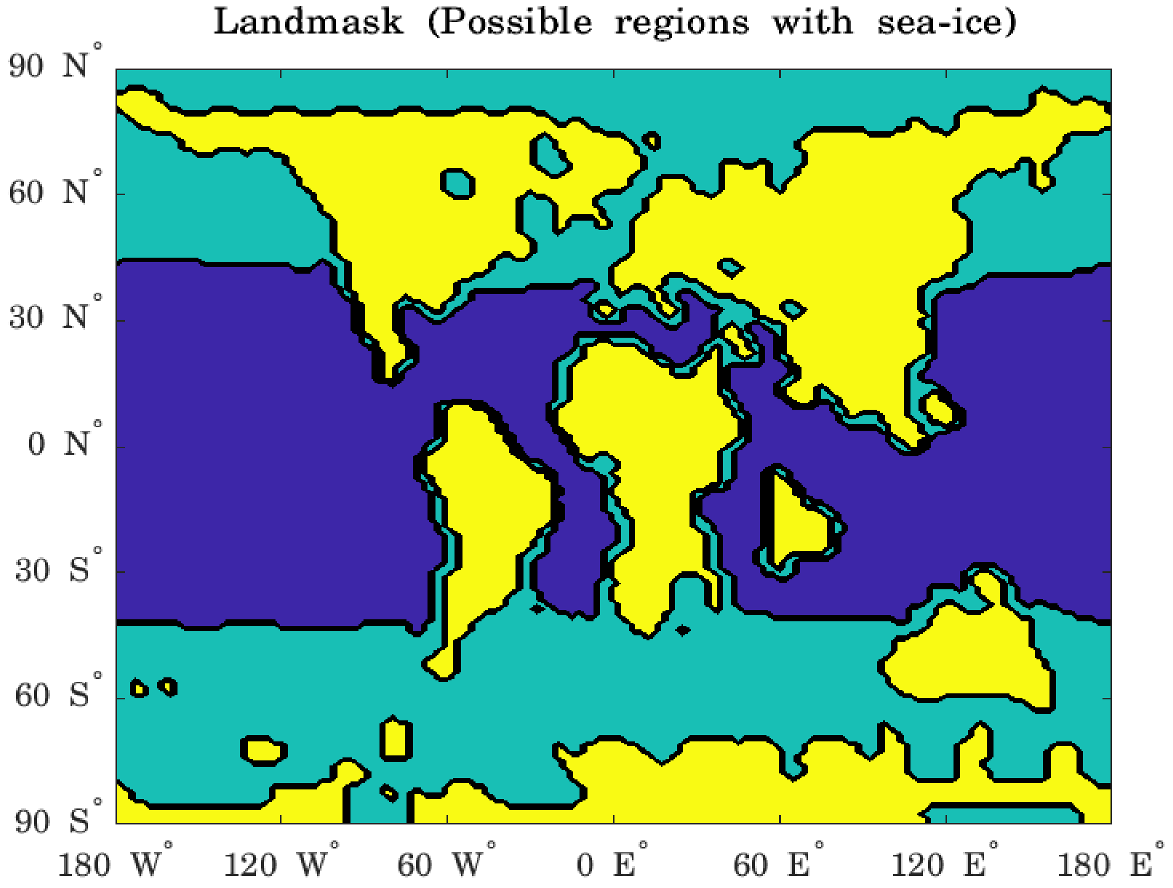


# Sea ice accretion possibility

The model currently lacks an ice-sheet model but we find that poleward of 45 N/S latitude, surface meteorological conditions over the ocean permits the existence of sea-ice after the impact.



# Conclusions and ongoing work

- We modified the planetWRF model to model the environmental conditions before and after the K/Pg boundary impact event.
- The impact winter is simulated successfully.
  - Land/sea temperature difference of ~50 K
  - Weakened tropospheric transport
  - Strong offshore conditions due to sea breeze
- Coupling with a 3D ocean model and ice-sheet model is under development
- Simulations using the inputs of newer hydrocode simulations [1] other than Pierrazzo et. Al [2]

[1] Artemieva, N., Morgan, J. +, Geophysical Research Letters, 44(20), pp.10-180. [2] E. Pierazzo et al., J. Geophys. Res. (1998).