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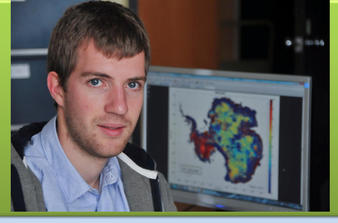

Geothermal heat flux uncertainties and the search for million year-old ice in Antarctica

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International Partnerships in Ice Core Sciences IPICS

ULB

The problem

•One of the major future challenges in the ice coring community is the search for a continuous and undisturbed ice-core record dating back to 1.5 million years BP, in order to resolve the mid-Pleistocene transition (MPT) enigma.[1]

•Finding suitable potential sites of **million-year old ice in Antarctica** requires:

- **•Thick ice** to resolve the signal at sufficient high resolution;
- •Sufficiently **high accumulation** to resolve lower layers;
- **•Slow-moving ice** to prevent distortions due to ice flow;
- **•Cold basal environment**, since old layers may not have melted away

•Conflict: thick ice = good insulator, which increases likelihood of temperate bed conditions

•Uncertainty: geothermal heat flux (GHF) is poorly known

Basal temperature corrected for pmp (°C)

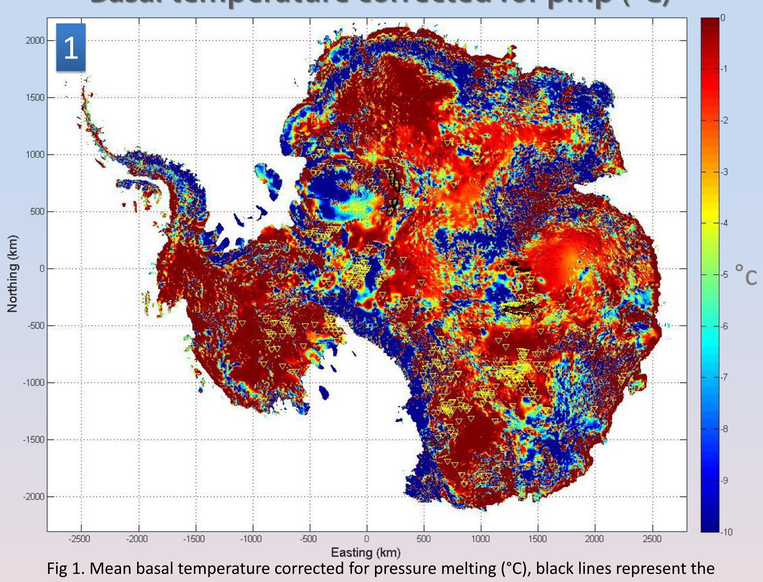


Fig 1. Mean basal temperature corrected for pressure melting (°C), black lines represent the major subglacial lakes, yellow triangles outline subglacial lakes discussed in Wright's paper [4].

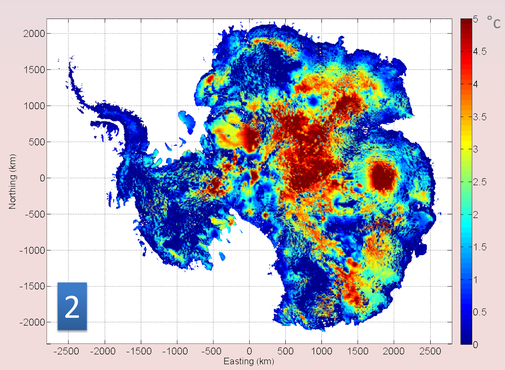


Fig 2. RMSE calculation (°C) based on 42 sensitivity experiments. Red colors indicate strong fluctuations of temperature but not necessarily a warm bed.

Fig 4. Likelihood of a cold bed based on RMSE calculation (°C). Dark and light blue indicate low and high fluctuations of RMSE, respectively .

Temperature likelihood *vs* ice thickness /speed

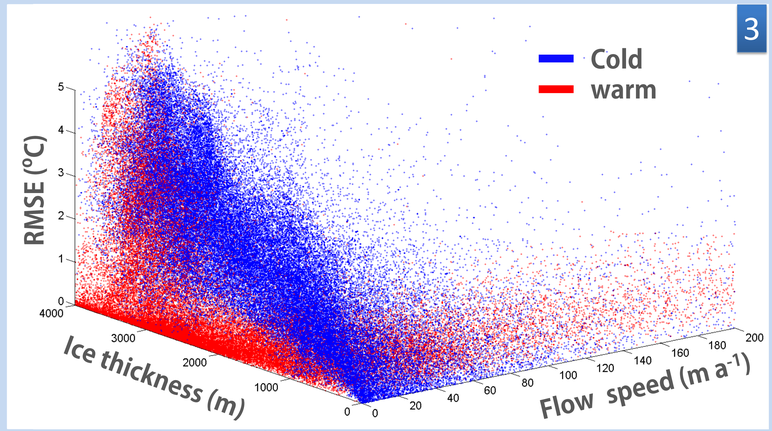


Fig 3. Distribution of velocity (m a^{-1}), thickness (m) and RMSE (°C), blue points represent likelihood of cold conditions and red points warm conditions

So, where to drill?

•Unfortunately, Antarctic ice sheet is generally warm-based, especially in interior where the ice is thick.

•Such conditions put severe constraints to drill for oldest ice (IPICS): the best places to drill are most likely the warmest.

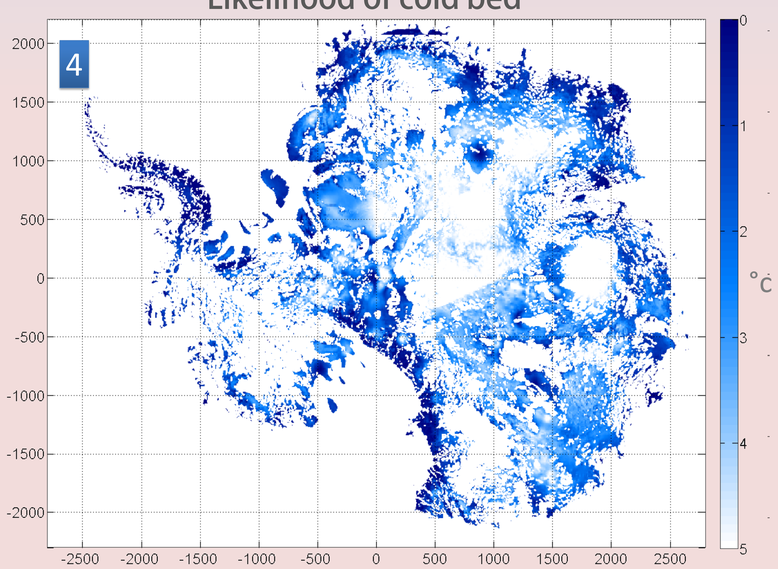
•Areas with lowest RMSE for cold-based conditions imply that despite uncertainty in boundary conditions, ice is likely cold.

•Subglacial mountain areas (Gamburtsev Subglacial mountains) are potentially of interest, but high local variability (not resolved by model) may lead to large variations (deeply incised valleys may be prone to temperate basal conditions).

•In the vicinity of known drill sites (Dome C, Dome F, Dome A), conditions may be favourable

•OUTLOOK: High-resolution (<1 km grid size) experiments near central areas

Likelihood of cold bed



The solution

•Methodology similar to Pattyn (2010), but updated and adapted to specifically delineating potential drill areas

•BASIS:

- •Thermodynamical model coupled with present-day ice sheet geometry and environmental conditions.[2]

•METHODOLOGY (and updates since Pattyn 2010):

- •Surface topography and ice thickness updated to Bedmap2 on 5 km resolution; [5]
- •Horizontal flow field obtained from heuristic rule combining interferometric velocities with modelled estimates.[3,2]
- •7 different sets of GHF: Fox Maule, Shapiro & Ritzwoller, Pollard, Puruker[6] and combinations of all;
- •Correction of GHF with measured temperature profiles & subglacial lake inventory[4];
- •Correction of surface velocities across large subglacial lakes with ice stream model.

•EXPERIMENTAL FRAMEWORK:

- •42 experiments (7 GHF datasets combined with different types of corrections on GHF using subglacial lake proxies, i.e. influence zones).

•RESULTS:

- •Likelihood of cold basal temperatures as a function of environmental and geometrical parameters

Where to drill ? - map of potential areas

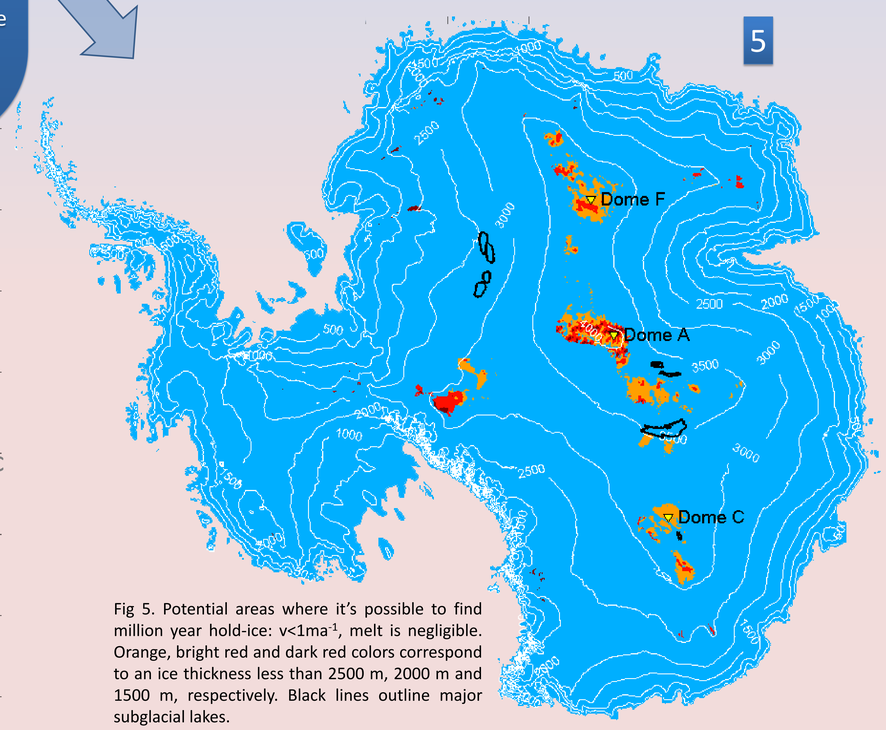


Fig 5. Potential areas where it's possible to find million year hold-ice: v<1ma^{-1}, melt is negligible. Orange, bright red and dark red colors correspond to an ice thickness less than 2500 m, 2000 m and 1500 m, respectively. Black lines outline major subglacial lakes.

References

1. Jouzel, J. and Masson-Delmotte, V., 2010. Deep ice cores: the need for going back in time, Quaternary Science Reviews, 29, 3683-3689.
2. Pattyn, F., 2010. Antarctic subglacial conditions inferred from a hybrid ice sheet/ice stream model, Earth Planet. Sci. Lett. 295, 451-461.
3. Rignot, E., Mouginot, J., Scheuchl, B., 2011. Ice Flow of the Antarctic Ice Sheet, Science 333, 1427-1429.
4. Wright, A. and Siegert, M., 2012. A fourth inventory of Antarctic subglacial lakes, Antarctic Science, 24, 659-664.
5. Fretwell, P., Pritchard, D. and Bedmap2 consortium, 2013. Bedmap2: improved ice bed, surface and thickness datasets for Antarctica
6. Puruker, M., 2013, Geothermal heat flux data set based on low resolution observations collected by the CHAMP satellite between 2000 and 2010, and produced from the MF-6 model following the technique described in Fox Maule et al. (2005), http://websrv.cs.umt.edu/isis/index.php/Antarctica_Basal_Heat_Flux