Why we don’t know how much it is snowing at the three poles – and how we can learn it

Michi Lehning et al.
Varun Sharma, Fränzi Gerber, Eric Sauvageat, Francesco Comola, Philip Crivelli, Christian Sommer, Hendrik Huwald, Nander Wever
Introduction: From Clouds to Ground

Processes

At the Snow-Atmosphere Interface

Seeding-Feeding
Precipitation Enhancement

Cumuliform Clouds
Updraft

Salting

Sublimation

Suspension

Erosion

Preferential Deposition

Rock Faces
Avalanches and Slides

Wind Stress

Wind

Saltation

Precipitation Elevation Gradient

Photo credits @ SLF/G.Darms
F. Gerber
Vertical wind velocity shows strong variations with effects on cloud dynamics and particle movement.

*Gerber et al., J. Hydrometeorology, 2018*
-> Make a link between measured snow distribution and precipitation

- Drifting and blowing snow is highly non-linear
- Sublimation losses are poorly constrained
- Mass «export» poorly constrained
- Snow deposition not understood

-> Let’s look at the physics
Mass Flux Measurements

East station, hourly means

West station, hourly means

Snow height evolution, hourly means

Eric Sauvageat, Hendrik Huwald
CRYOS, EPFL laboratory of the WSL/SLF
Full Physics in an LES Model

NUMerical solution

\[
\frac{dm_p}{dt} = \pi D d_p \rho_f (\tilde{q} - q_{p, surface}) \, Sh
\]

\[
c_i \, m_p \frac{dT_p}{dt} = L_s \frac{dm_p}{dt} + \pi K d_p (\tilde{\theta} - T_p) \, Nu
\]

Thorpe and Mason (TM) model

\[
\frac{dm_p}{dt} = \frac{\pi d_p (\sigma_* - 1)}{\kappa T_{a, \infty} \, Nu \left( \frac{L_s M}{RT_{a, \infty}} - 1 \right) + \frac{1}{\mathcal{D} \rho_s (T_{a, \infty}) \, Sh}}
\]

\[
L_s \frac{dm_p}{dt} = -\pi K d_p (\tilde{\theta} - T_p) \, Nu
\]

Varun Sharma, Francesco Comola

CRYOS - EPFL laboratory of the WSL/SLF
It is all Barchan Dunes:
- Snow Immobilization
- Sublimation
- Precipitation
- Surface Mass Balance
Deposition of Snow in Antarctica:
- Initial Deposition is soft
- No hardening without drifting
- Hardening at wind-exposed locations only
- Spatial hardening pattern not fully explained yet
Conclusions - Outlook

- Non-linear processes between “clouds and ground” introduce a large uncertainty in large-scale modelling and prediction.
- Progress in disentangling processes is being made and leads to an increase in quantitative understanding.
- Upscaling from single (snow) particle dynamics to snow distribution is slowly happening.
- **Link to (Model) precipitation is the current challenge.**
OSC Presentations

* From the Clouds to the Ground - Snow Precipitation Patterns in Complex Terrain | **Wednesday** 09:00 | Presenter: Gerber, Franziska

* Local Surface Mass and Energy Balance Processes in East Antarctica | **Friday** 09:00 | Presenter: Huwald, Hendrik

* The Role of Particle Cohesion in the Wind-driven Erosion of Snow | **Friday** 09:00 | Presenter: Comola, Francesco

* Revisiting the Thorpe-Mason model for calculating sublimation of saltating snow | **Friday** 09:00 | Presenter: Sharma, Varun

* Wind-packing of Snow in Antarctica | **Wednesday** 17:30 | Presenter: Sommer, Christian

EPFL laboratory of the WSL/SLF - EPFL