Solid Precipitation Measurements at the NSA Observatory

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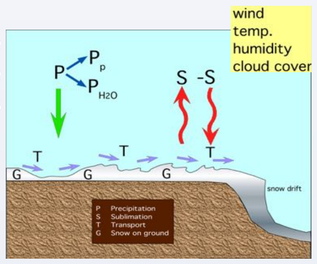
The Winter Water Balance in the Arctic

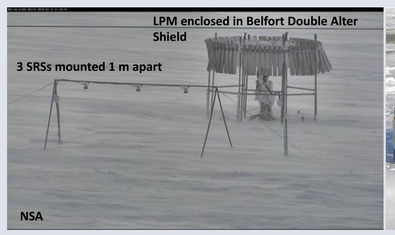
- The particle flux (P_p) that impacts the radiation balance is closely related to the mass flux (P_{H2O}) that accumulates as snow on the ground.
- This accumulation is augmented by condensation (-S) or reduced by sublimation (S) by vapor fluxes that vary with wind and snow transport.

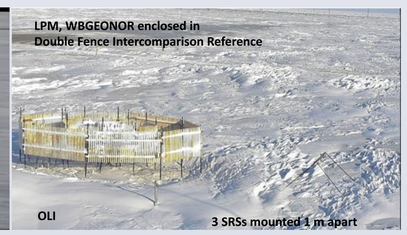


- Transport (T) creates drifts, snow deposits that conveniently provide an integrated measure of T.
- The residual of all of these processes (G) is the standing snow pack.
- Environmental variables control the nature and flux rate of the solid precipitation, as well as the intensity of T and S.

New: Detailing Precipitation by Disdrometer (LPM)

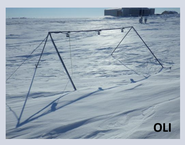
- The Laser Precipitation Monitor is a "real time" weather instrument; provides high-resolution time-series of precipitation phase, intensity, particle size distribution and fall velocity.
- When a particle falls through the light beam, the receiving signal is reduced.
- Particle diameter is calculated from the amplitude of the reduction.
- Fall speed is determined from the duration of the reduced signal.





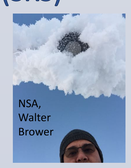
New: Total Precipitation by Gauge (WBGEONOR)

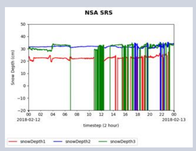
- The Geonor All-Weather Precipitation Gauge uses vibrating wire load sensors to weigh the precipitation catch (weighing bucket); no mechanical parts.
- Precipitation accumulation reported in real-time.
- Heating element along rim to prevent ice and snow build-up. Mentors are analyzing data stream for signs of ice deposition and slush in the Geonor bucket.



New Data: Measuring Snow Depth by Sounding (SRS)

- Campbell Scientific SR50a sensors have been used world-wide to record snow depth.
- Continuous measurements provide a snow depth value accurate to about ±1 cm.
- SRS data has been noisy over the course of the winter, but it is correctable. Causes could be wind, particles blown into sensor cavity, or rime buildup. We are working with Campbell Scientific to resolve this issue.





Solid Precipitation Measurement Strategy

On the North Slope of Alaska, leading-edge precipitation instrumentation has been installed over the past few years. ARM/ASR scientists can now examine:

- Amount and phase of precipitation over minutes, hours, days, seasons
- Linkages between wind, snow on the ground, and snowfall

An outside laboratory is also being established at University of Alaska Fairbanks to monitor the performance of the newest instrumentation (LPM, WBGEONOR, SRS) under adverse conditions to come up with guidelines for operation at NSA and OLI.

Instrument, Manufacturer *Mentor*	Measurements	Sites	Fence	Data Name	Data Level
SR50a Campbell Scientific, Inc. *M. Sturm*	Snow depth	NSA OLI UAF		SRS	a1^^
T-200B All-Weather Precipitation Gauge, Geonor, Inc. *M. Sturm*	PA	NSA** OLI UAF	X	WB-GEONOR	a1^^
Present Weather Detector, Vaisala, Inc. *J. Kyrouac*	PA, PI, PT, Viz	NSA OLI UAF		PWD MET	b1
Laser Precipitation Monitor, Thies Clima, Inc. *M. Sturm*	PA, PI, PT, SD, VF, Viz	NSA OLI UAF	X	LPM	a1^^
Multi-Angle Snowflake Camera Particle, Flux Analytics & U. Utah *M. Stuefer, T. Gordon*	HS, SD, VF, imaging	OLI	X	MASC	b1
Precipitation Imaging Package, NASA *M. Stuefer, T. Gordon*	HS, SD, imaging	OLI		PIP	b1

PA, precipitation accumulation; PI, precipitation intensity; PT, precipitation type; HS, hydrometeor shape; SD, hydrometeor size distribution; Vf, fall velocity; Vis, visibility.
^^ Data not yet available at the ARM data archive. Expected Spring 2018.
** The Geonor at NSA is operated by NOAA.

2018/2019 Instrument Modifications

- Move the OLI LPM into its own Belfort Double Alter Shield, consistent with NSA configuration
- Add 3 more SRSs to OLI, NSA; install perpendicular to current SRSs to capture more information on snow transport across the tundra.
- Add cameras to better document rime and snow build-up on instruments to better understand the snow environment within meters of the instruments.

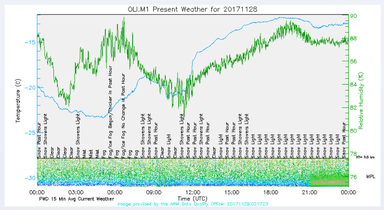
Future Instrumentation

- An LPM on the ARM NSA tower – measurements would capture the falling particles, not the particles blowing across the surface.
- An LPM mounted vertically at NSA – measurements, paired with the horizontally mounted LPM, would paint a 3-D picture of the pathway of blowing and falling particles.
- A larger array of snow depth sensors would further improve our understanding of snow transport at the NSA observatory.

Opportunities for Comparison

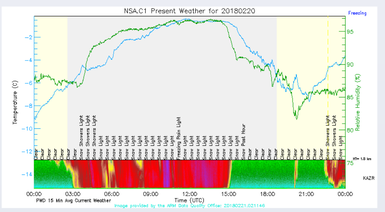
Light precipitation in wind conditions typical of the Arctic is notoriously difficult to measure. Wind alters the snow trajectory around the instruments. A wealth of data is being collected at NSA/OLI to intercompare similar measurements under varying conditions. Routine inspections by the on-site technicians are invaluable to these pursuits!

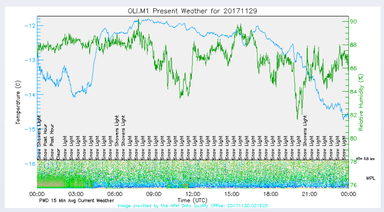
OLI: Light Snow, Nov 2017

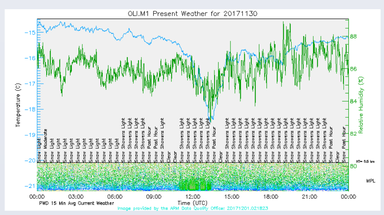


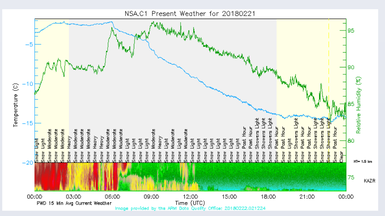
Precipitation events from OLI and NSA are presented. Wind speeds are often higher when precipitation is reported. Note the response of the snow depth to wind changes.

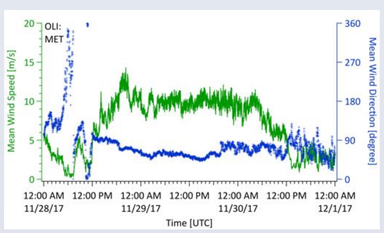
NSA: Snow & Drizzle, Feb 2018

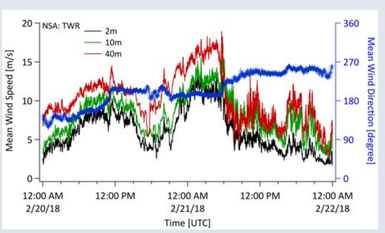


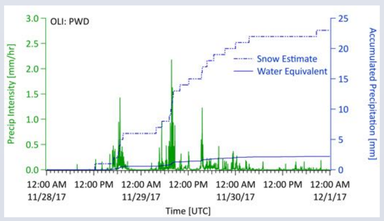


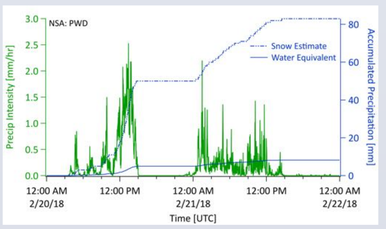


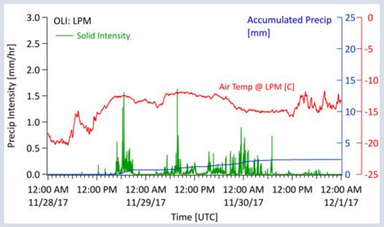


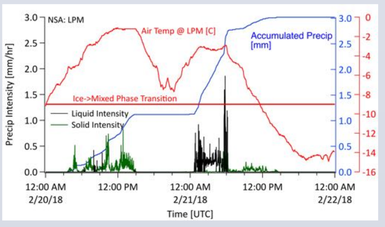


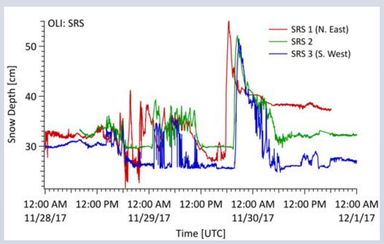


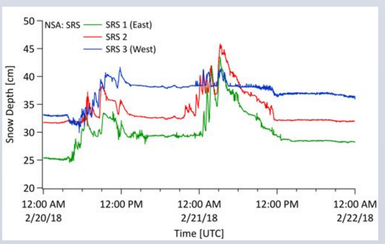












Upcoming data analysis efforts

- Compile 2017/2018 NSA/OLI snow season statistics and compare like measurements. Look for trends in snow fall and snow transport as a function of wind. Can we tell when instruments might be rimed over? What can we gleen about the role of fences in the precipitation measurements?
- Begin analysis of the particle distributions and fall velocities from disdrometer and imaging instruments.
- Provide new guidance to the site operators to improve instrument performance for the 2018/2019 snow season!