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GLOBSNOW RER-meeting
Current State of the art for SWE monitoring

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SWE monitoring – Passive Microwave sensors

- Traditionally 19 & 37 GHz are utilized
- 10 GHz may enhance retrievals on boreal forest zone (Derksen et al. in press)
- Use of W-band frequencies may enhance spatial resolution

	SMMR	SSM/I	AMSR-E
Years of operation	Oct. 1978 – Aug. 1987	July 1987 – present	June 2002 – present
X-band	10.7 GHz	-	10.7 GHz
K/Ku-band	18.0 GHz	19.35 GHz	18.7 GHz
Ka-band	37.0 GHz	37.0 GHz	36.5 GHz
W-band	-	85.5 GHz	89.0 GHz

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Passive microwave SWE monitoring - Algorithms, Current data sets

- Typical empirical SWE algorithms utilize channel difference
  - 37 – 19 (V or H pol)
  - 19 – 10 (V pol)
- Methodology based on Chang et al. 1987
- Different adaptations for different regions (e.g. Canada)
- Largest problems
  - Performance for shallow or deep snow packs (saturation of 37GHz scatter on deep snow)
  - Regional adaptations do not perform on global scale
  - Varying vegetation, land use and lakes effect SWE retrievals
- Currently available Global SWE datasets
  - AMSR-E daily SWE dataset from 2002 – present (NSIDC)
  - SMMR & SSM/I monthly dataset 1978 – 2003 (NSIDC)
- Regional SWE datasets
  - Canada (1978 – present)
  - FMI Eurasian Snow Cover (1978 – present)

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Available SWE products

Name	***Sensor(s)***	***Resolution***	***Interval***	***Availibility***	***Region***
Global Monthly EASE-Grid Snow Water Equivalent	SMMR SSM/I	25 km EASE grid	monthly	1978 - 2003	Northern and Southern Hemispheres
AMSR-E/Aqua Daily L3 Global Snow Water Equivalent EASE-Grid products	AMSR-E	25 km EASE grid	Daily 5-days monthly	19 June 2002 - present	Northern and Southern Hemispheres
Global EASE-Grid 8-day Blended SSM/I and MODIS Snow Cover	MODIS SSM/I	25 km EASE grid	8-days	5 March 2000 - present	Northern and Southern Hemispheres
Passive microwave SWE data for the Canadian Prairies (EC)	SMMR SSM/I, AMSR-E	EASE-Gridded 25x25 km data	Daily	1978 to 2008	Western Canada
FMI Eurasian Snow Cover monitoring	AMSR-E, SSM/I Ancillary data	Lon-lat 0.25 degree grid	Weekly or bi-monthly	March 2007-present	Northern Eurasia

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AMSR-E Daily L3 Global SWE product

- Daily, 5-day or monthly averages
- sea, wet snow, precipitation and probability of snow screening
- SWE estimate based on simple channel difference (Chang et al., 1987; Chang et al., 1997;)
- Enhancements made to original algorithm continue

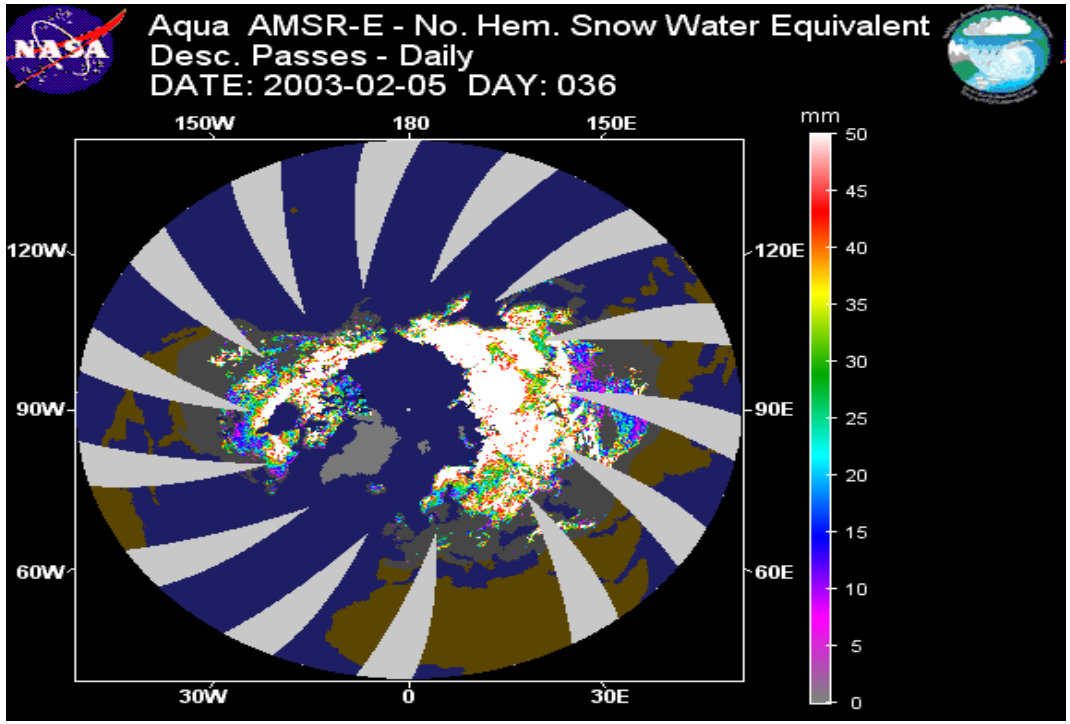

Image courtesy of Matt Smith, Information Technology & Systems Center, University of Alabama at Huntsville

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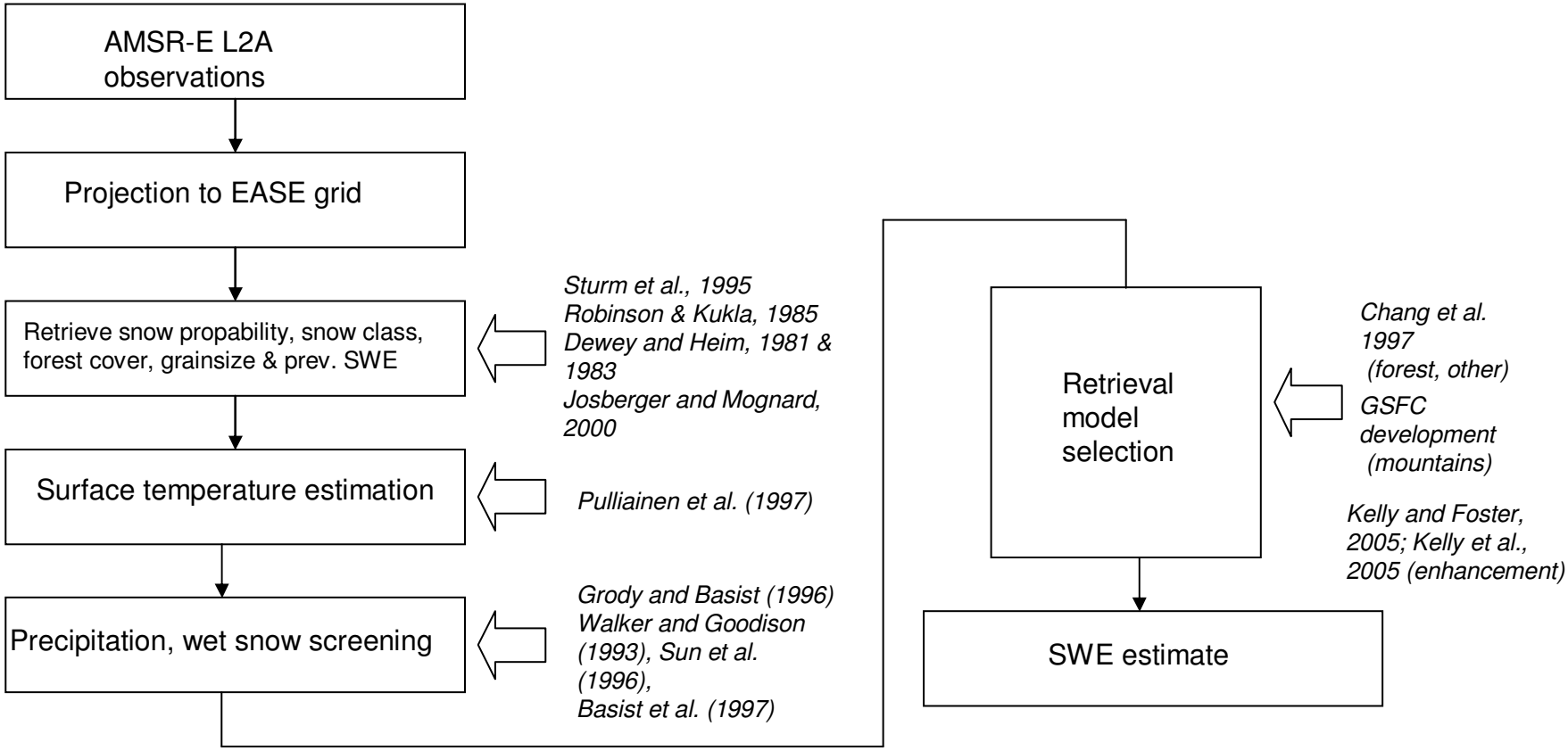
AMSR-E Daily L3
Global SWE product: flow chart



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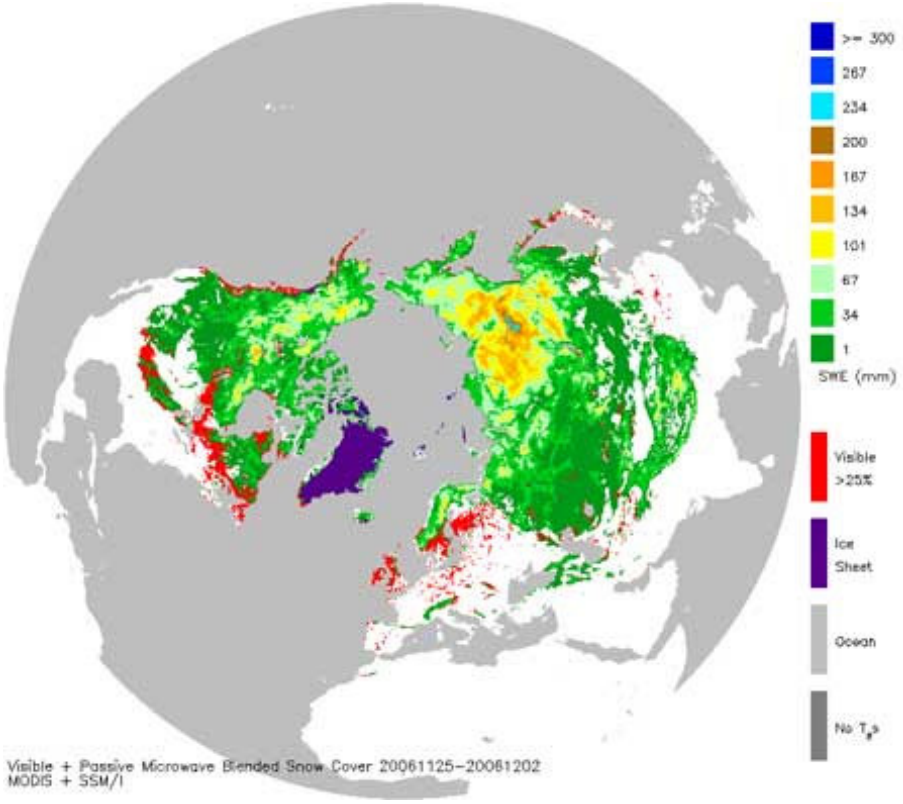
NSIDC: Blended SCA and SWE

- SCA derived from 8-day MOD10C2 data, regridded to 25 km EASE-Grid.
- Deep snow SWE: modified Chang et al approach (SSM/I 37H-19H).
- Shallow snow SWE: 19V-37V and 37V-89V differences.
- Adjustments made for forest cover %.
- False SWE signals filtered using snow frequency climatology.
- 8-day data available from March 2000 (monthly SWE climatology also available).



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FMI Eurasian Snow Cover monitoring

Assimilation of satellite data with *in situ* observations (snow depth/temperature from weather stations)

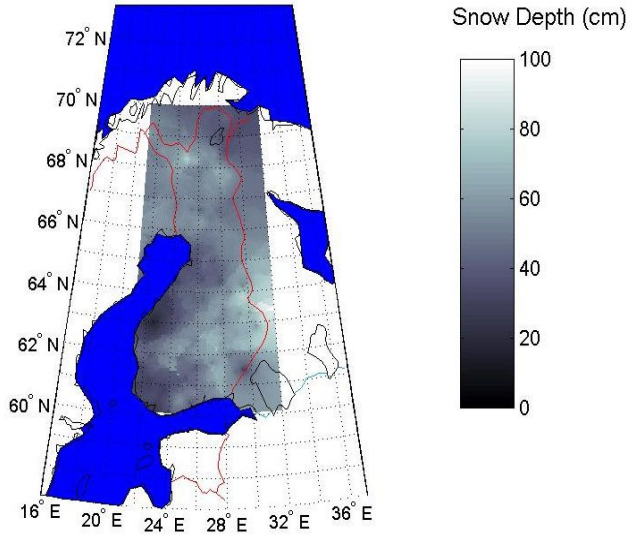
• Kriged daily effective grain size background field (determined by adjusting HUT model to weather station SD)

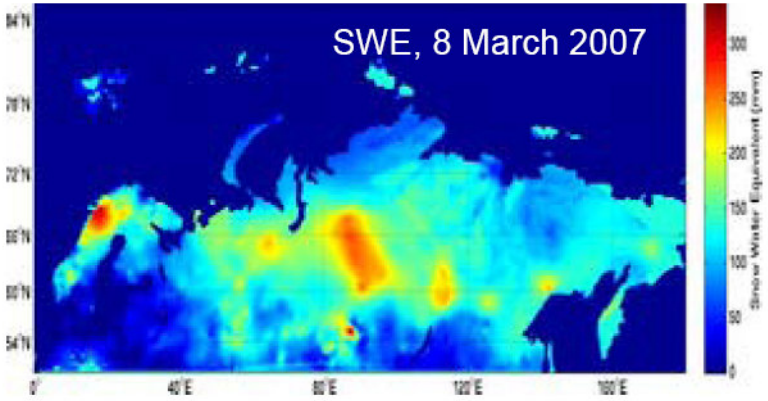
•National dataset produced at FMI, Eurasian dataset for GMES.

➢Kriged daily SWE or SD background field.

•Validation against snow course data (Finnish snow courses + INTAS-SCONE)

➢ Potential for hemispheric application through ESA GlobSnow





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Environment Canada Algorithm Suite

Empirically derived algorithms for specific land cover regions developed from ground and airborne campaigns.

I. Prairies (Goodison et al., 1980's)

II. BOREAS (Chang et al., Goita, Goodison, Walker, 1990's)

III. Northern regions (2005 onwards)

<u>Open canopy northern boreal forest</u>
-Influence of vegetation
-Deep snow

<u>Sub-Arctic tundra</u>
-Influence of lakes
-Snow heterogeneity

Regional SWE retrievals provided to operational users (flood forecasting; hydro-electric generation) and utilized for climatological analysis, NWP data assimilation, and climate model evaluation.

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SWE Algorithm Summary (Canada)

SWE Algorithm	Approach	Experiments	References
Open prairie with wet/patchy snow indicator	**37V-19V**	**Saskatchewan 1982**	**Goodison and Walker, 1995** **Walker and Goodison, 1993**
Southern boreal forest	**37V-19V** **(Separate equations for deciduous, coniferous, and sparse forest cover)**	**BOREAS 1994;** **Prince Albert 2003**	**Goita et al., 2003**
Northern boreal forest	**19V-10V**	**Manitoba 2004-2007;** **NWT 2005-2007**	**Derksen, 2008**
Lake rich sub-arctic tundra	**37V**	**NWT 2005;** **SnowSTAR 2007;** **IPY 2008**	**Derksen et al., in press**

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Summary of current methodology & Anticipated improvement in GlobSnow

1) Current long term datasets on Global scale

- Monthly from 1978, daily from 2002

GlobSnow: Daily 15 years (… from launch of SSM/I 1987?, SMMR 1978?)

2) Thematic accuracy for the current methods

- On global scale 40mm – 200mm
- On regional scale 20mm – 50mm ?? (Depending on methodology)

GlobSnow: Target accuracy of 30 – 50 mm on global scale (Achieved through assimilation of EO-data and ground-based weather station observations)

3) Error estimates (error bars)

- Current methods do not provide information on estimation error

GlobSnow: Error estimates for each SWE estimate (through assimilation)

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Requirements summary

Snow water equivalent	State of the Art	Proposed GlobSnow product	User requirements
Coverage	Global	Northern Hemisphere (excluding mountainous areas)	
Time period	Monthly starting from 1978 Daily starting from 2002	minimum 15 years up to present	
Temporal frequency	Monthly starting from 1978 Daily starting from 2002	daily, weekly (7 days) and monthly products	
Spatial resolution	Global: 25 km EASE-grid	Northern Hemisphere: 10 km EASE-Grid	
Geometric accuracy	sub pixel location error	sub pixel location error	
Thematic accuracy	40 – 200 mm	Areas with dense weather station network: 25-35 mm Areas with sparse weather station network: 30-40 mm	
Accuracy characteristics (Error statistics)	Not Available	Each sample has an error estimate	