

Validation methods of snow cover

Accuracy, stability, horizontal resolution, and vertical resolution

ECV: Snow cover	GCOS/CEOS Action T16		
	Property		
		Snow area	Snow water equivalent
Accuracy	Target	5%	10 mm
	Planned	5%	TBD
Stability(/decade)	Target	4%	10 mm
	Planned	5%	TBD
Horizontal resolution (km)	Target	1 100 m in complex terrain	1
	Planned	TBD	TBD

For SWE:

- Accuracy: bias or RMSE?
- The required resolution is too high to be met.

the CEOS Response to GCOS Implementation Plan 2010 (IP-10)

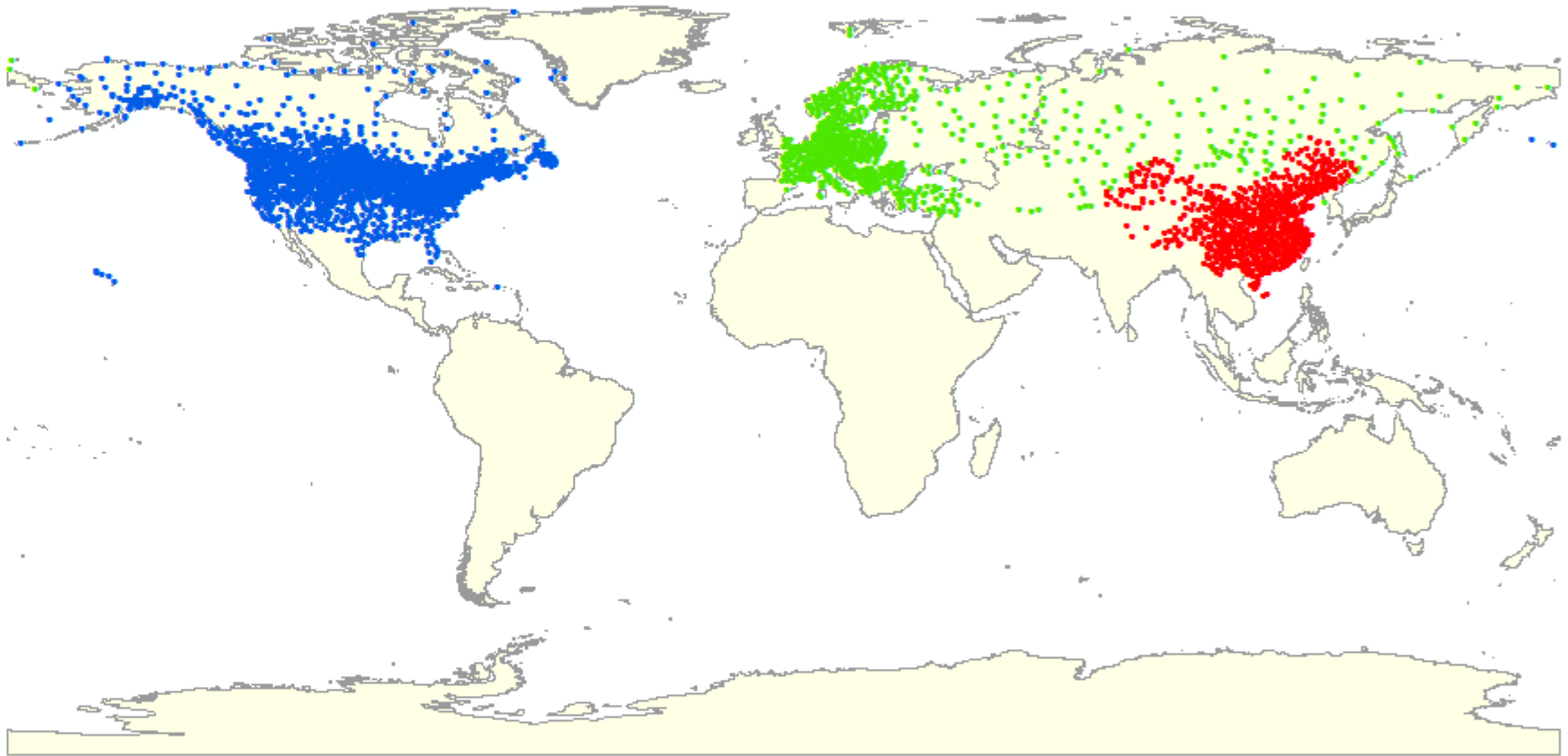
Datasets for Validation

- Ground measurements (point scale)
 - Directly validation
 - Interpreted spatial distribution
- High resolution images
 - TM, ETM+, Landsat 8 OLI/TIRS
 - SPOT, HYPERION
 - ZY, HJ
 -
- Inter-comparison

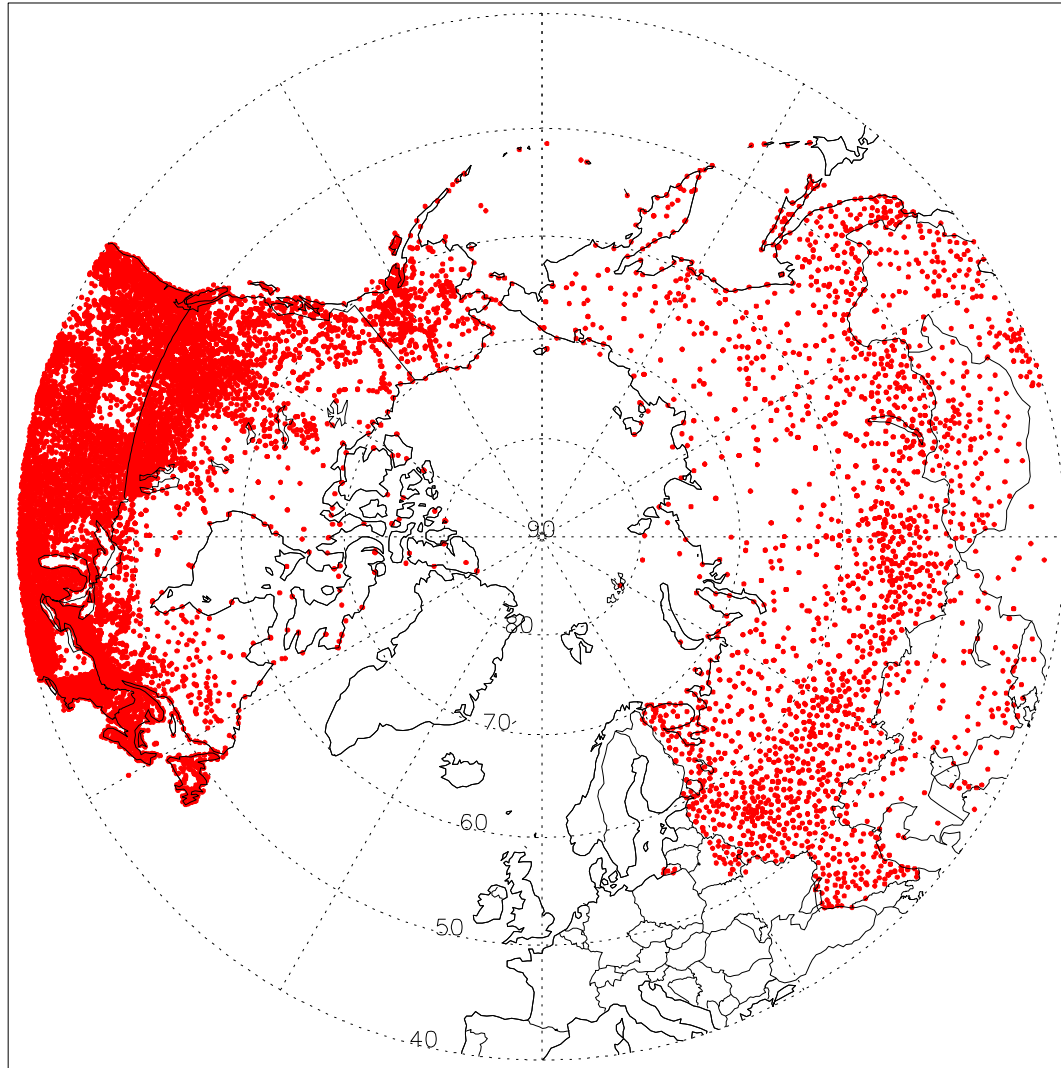
- **Validation from in situ data**
- The most common way to validate the snow water equivalent data products, and some cases for snow cover area data products.

Available *in situ* data

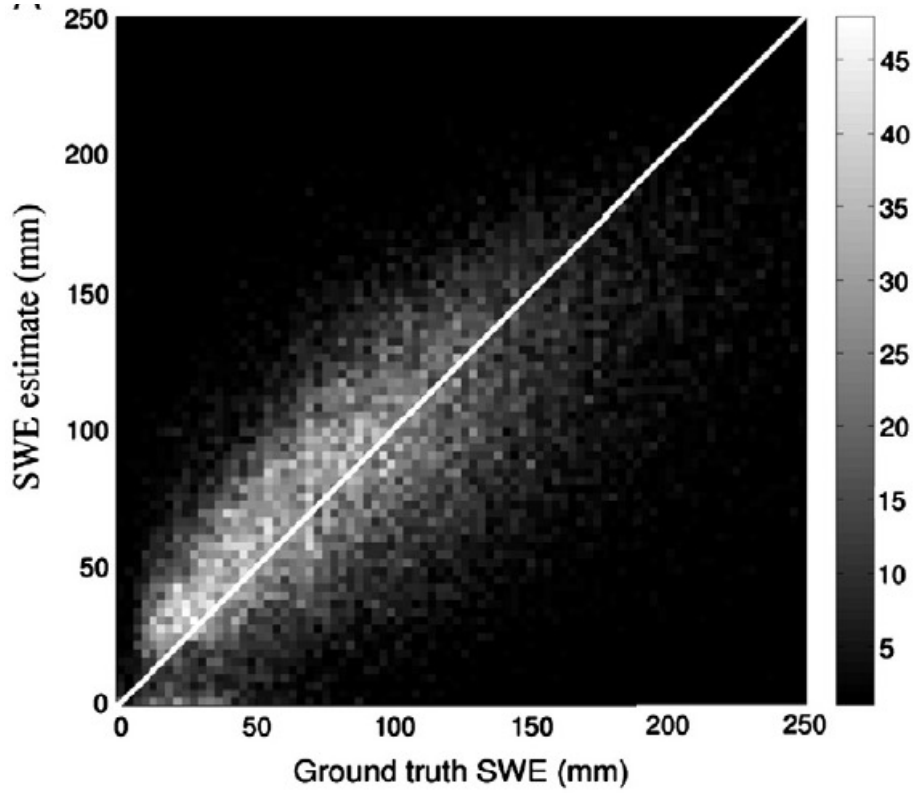
- 1) The Former Soviet Union Hydrological Snow Surveys (1345 sites; 91 snow course transect)
- 2) The Historical Soviet Daily Snow Depth Version 2 (HSDSD) product is based on observations from 1881 to 1995 at 284 World Meteorological Organization (WMO) stations
- 3) NOAA provides NWS/COOP Snow Depth and Snowfall Graphics and Data (www.cpc.ncep.noaa.gov/products/season_update/snow_map/)
- 4) Daily snow depth data for 1062 observing stations across the contiguous US covering the period 1871-1997 are available from the Carbon Dioxide Information and Analysis Center (CDIAC) <http://cdiac.ornl.gov/>
- 5) Daily snow depth data for Canada at several 1000 stations
- 6) Snow depth and water equivalent are also observed by other national, state, provincial and private networks in many countries on a daily, ten-day or monthly basis.



Blue and green sites has been used in GlobSnow products
Red sites not be included.



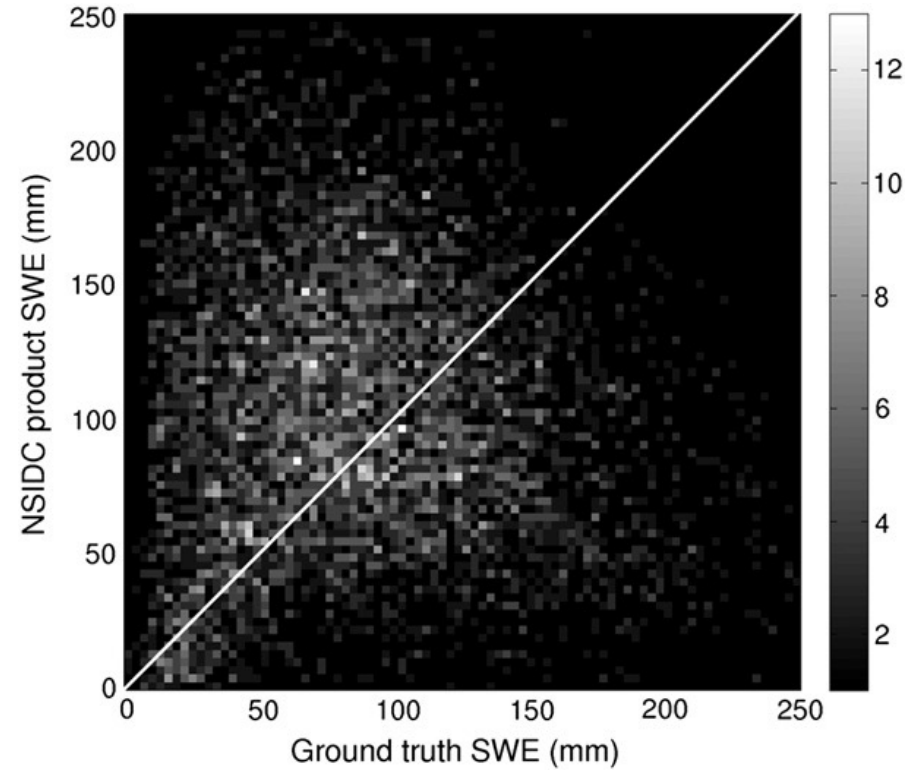
We are collecting snow measurements from these sites.



GlobSnow vs. Ground SWE

Season	RMSE (mm)	bias(mm)	Corr. coeff	Samples
Fall	23.0 (21.7)	5.8 (6.5)	0.69 (0.70)	35 197 (34 943)
Winter	37.7 (28.9)	1.7 (7.7)	0.72 (0.72)	165 784 (150 405)
Spring	72.5 (47.3)	-37.6 (-19.3)	0.53 (0.47)	42 843 (33 189)

RMSE= 47 mm

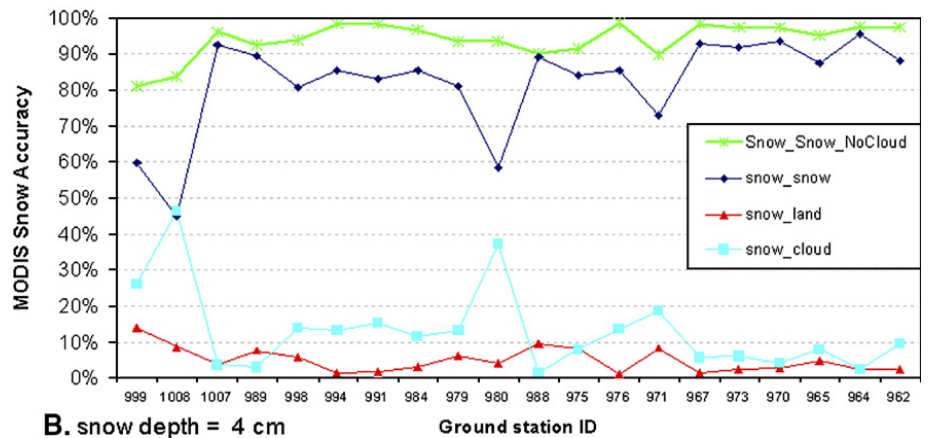
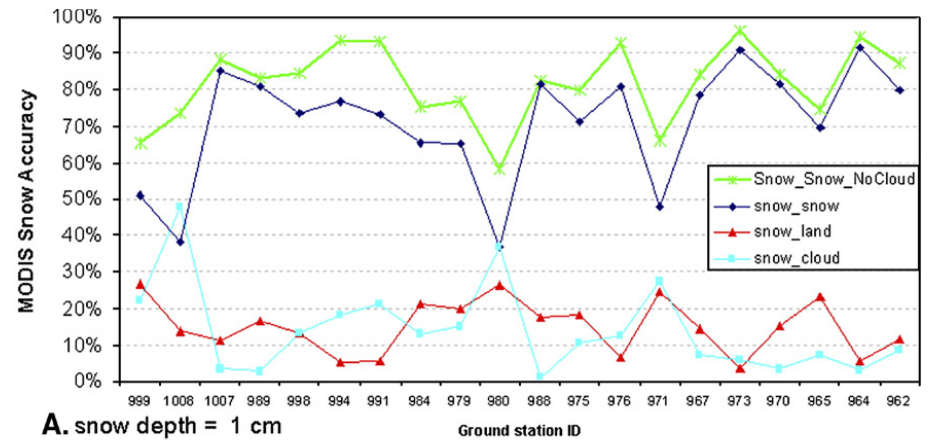
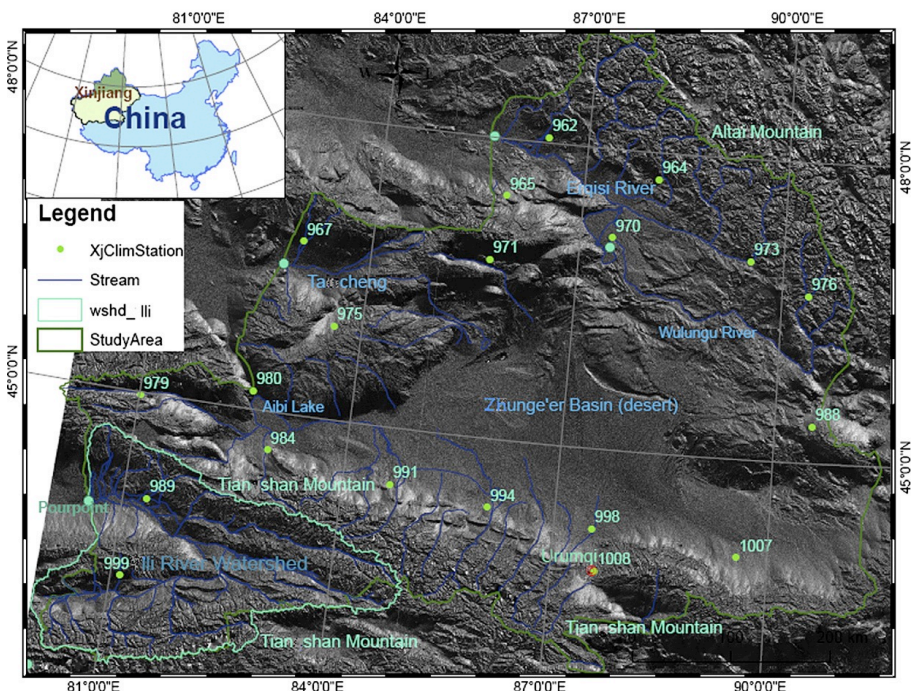


RMSE= 92 mm

NSIDC SWE vs. Ground SWE
(Takala, RSE, 2011)

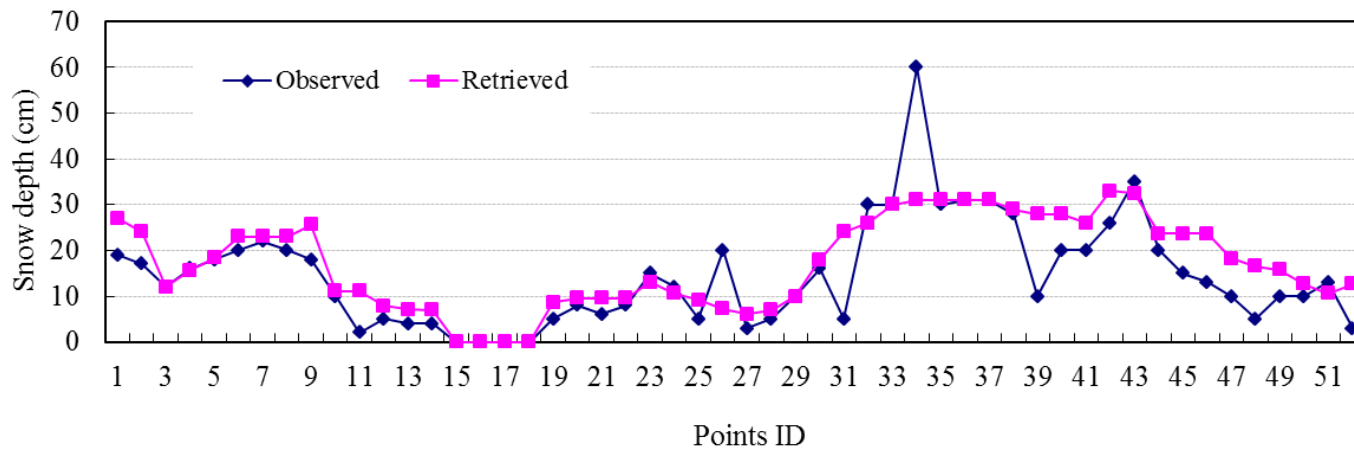
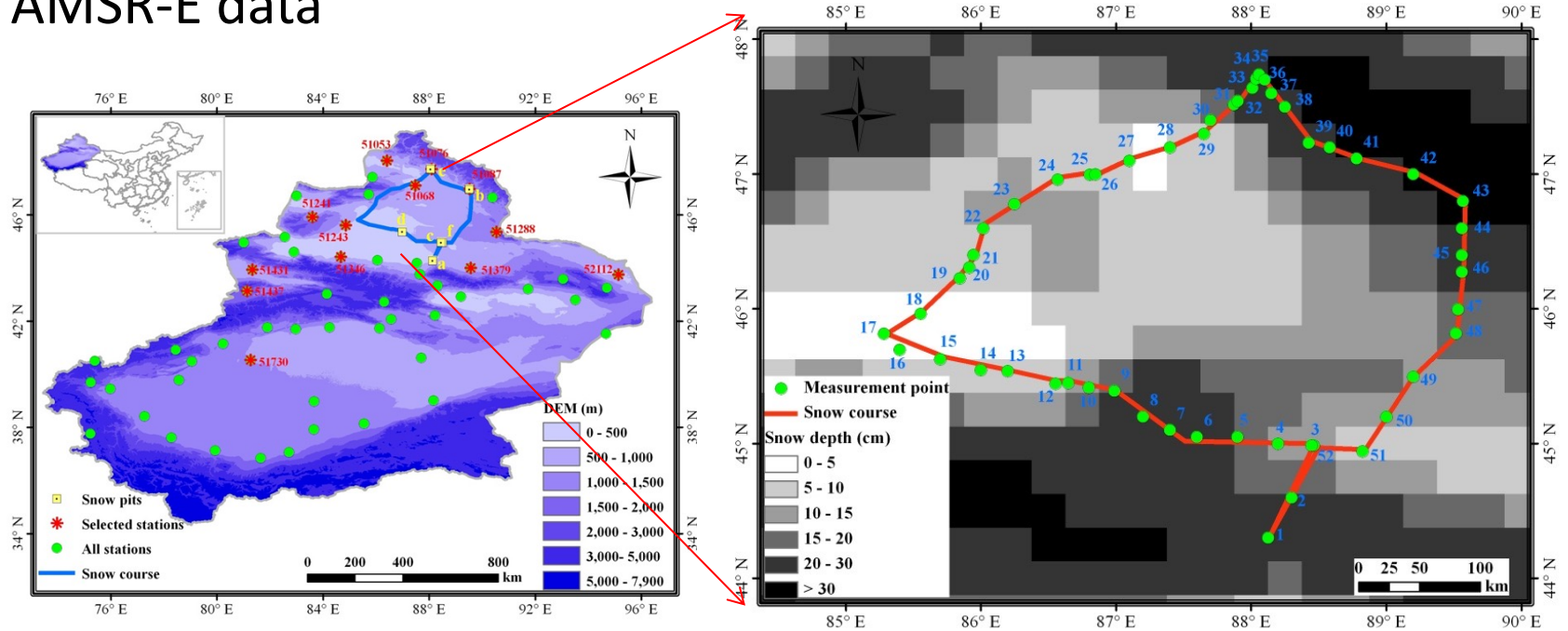
Evaluation of MODIS snow cover and cloud mask in Northern Xinjiang, China by using the snow observations in the meteorological stations.

Study Area: the North of Xinjiang Uygur Autonomous Region, China

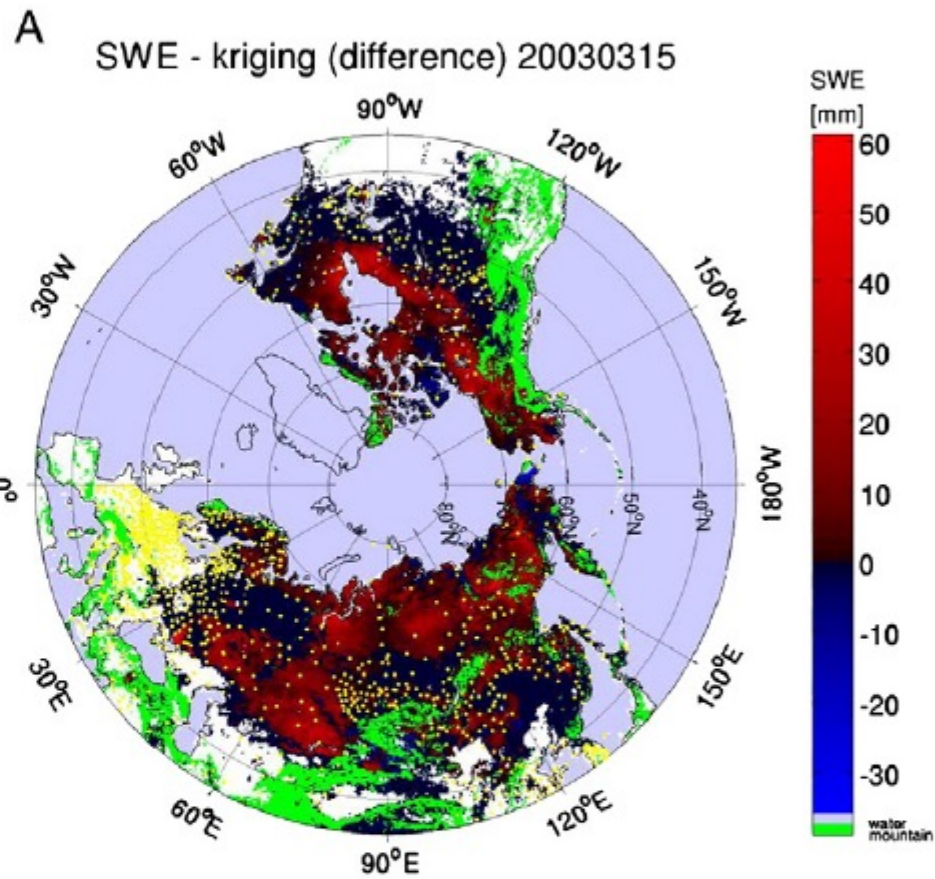


(Wang, RSE, 2008)

Snow depth and snow water equivalent estimation from AMSR-E data

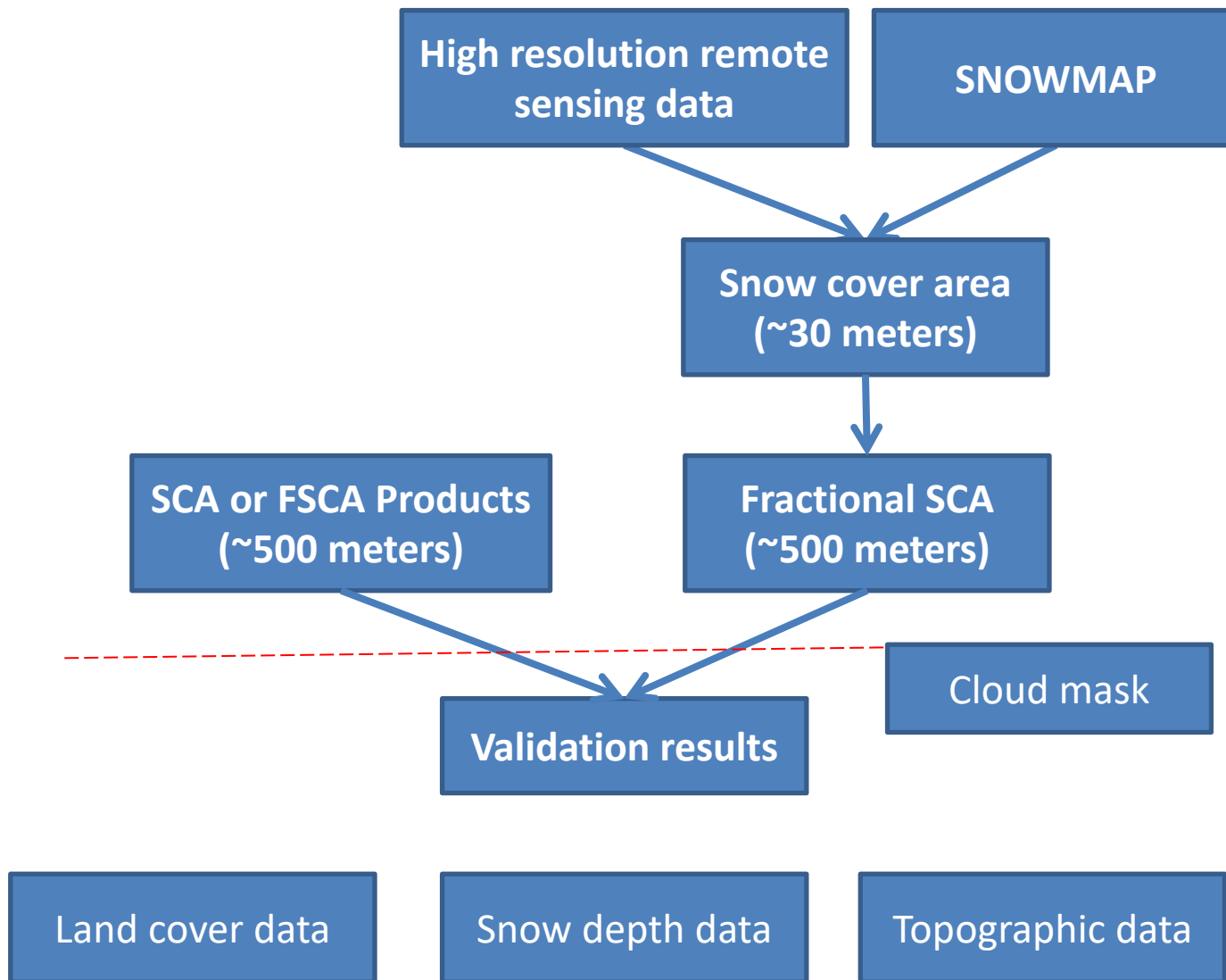


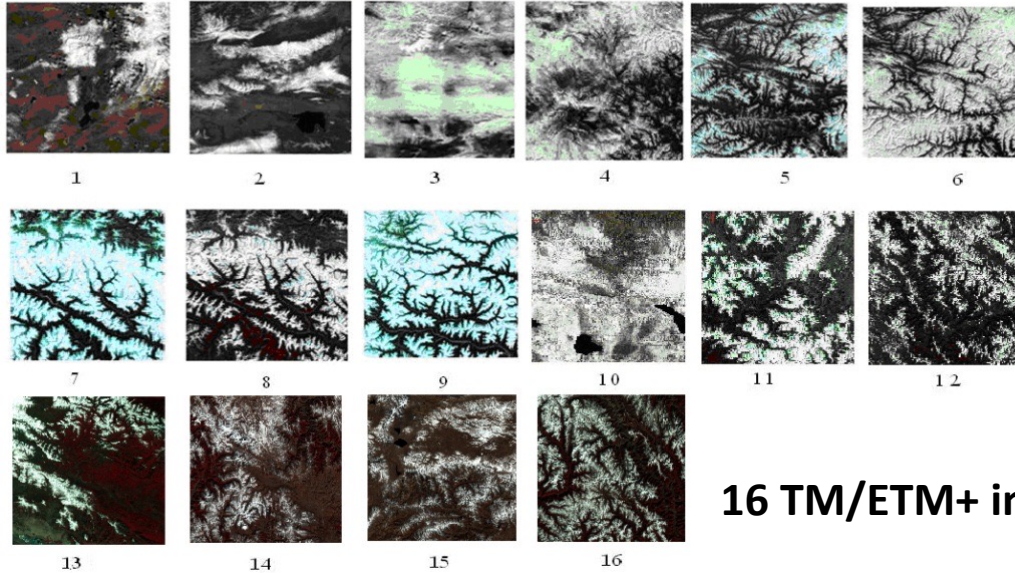
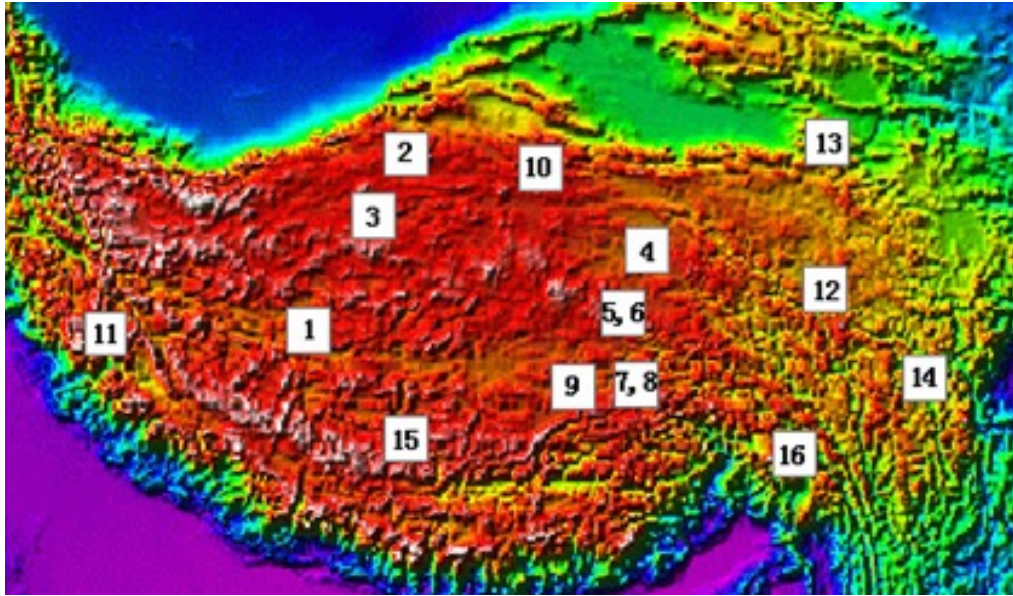
(Dai, RSE, 2012)



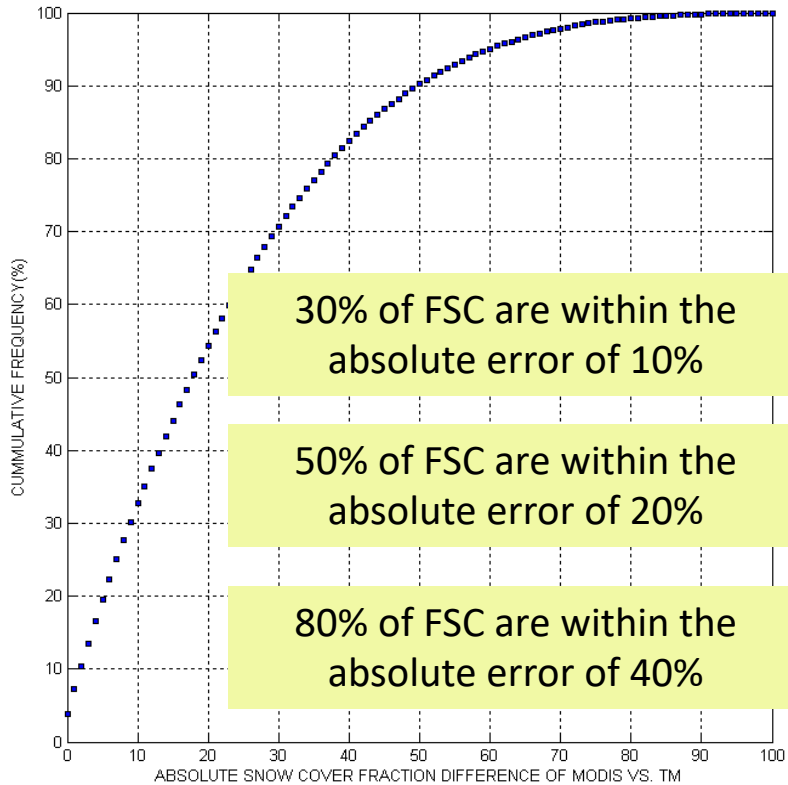
(Takala, RSE, 2011)

- **Validation by high resolution remote sensing data**
- It is the most common method to validate the snow cover area data products

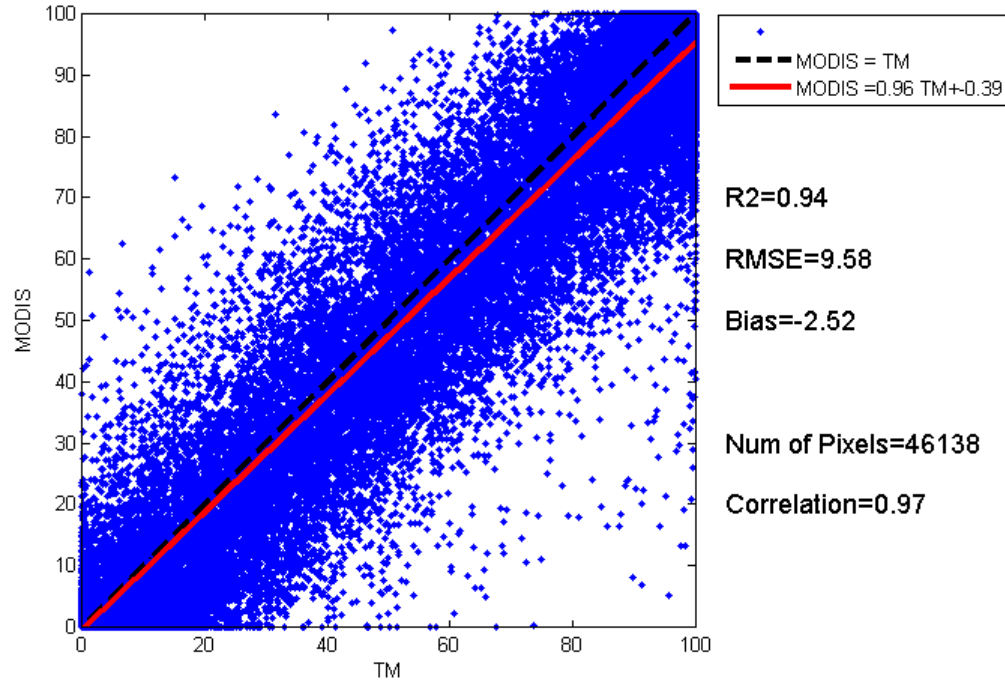




16 TM/ETM+ images

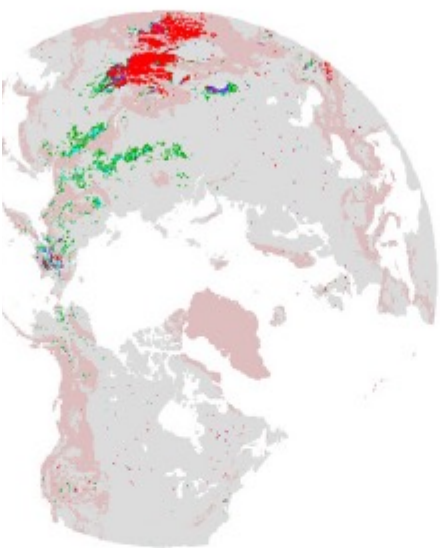


Accumulative histogram of MODIS FSC absolute error

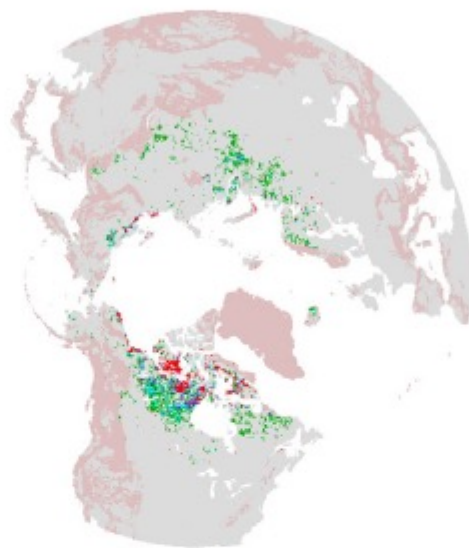


Scatter plot of MODIS and TM FSC aggregated to spatial resolution of 2km

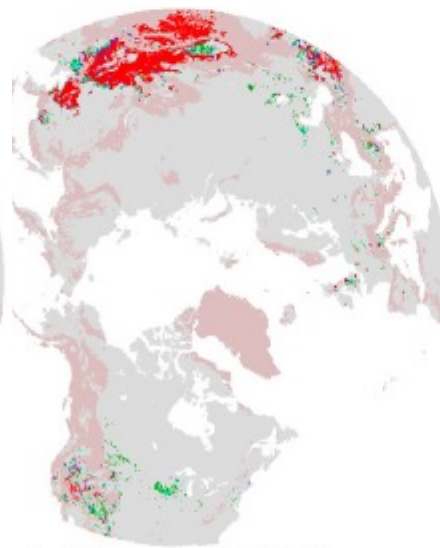
- Inter-comparison



(a) October AMSR-E snow



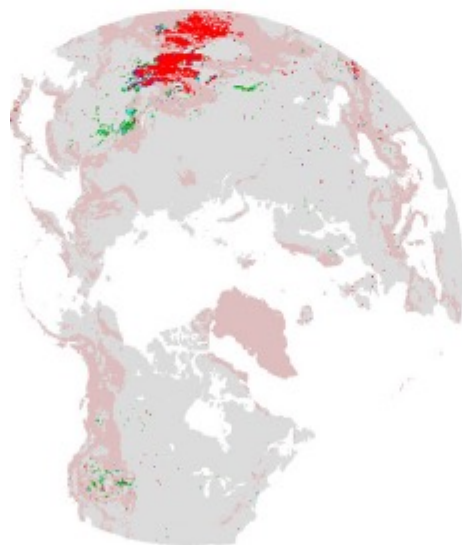
(b) October AMSR-E no-snow



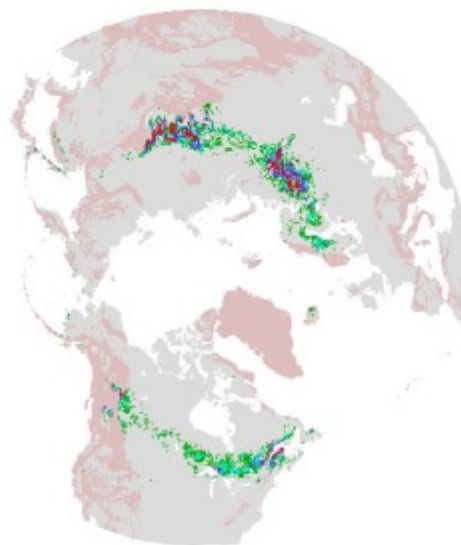
(c) January AMSR-E snow



(d) January AMSR-E no-snow



(e) April AMSR-E snow



(f) April AMSR-E no-snow



AMSR-E SWE, MODIS snow cover area, and IMS snow cover area

(Frei, Advances in Space Research, 2012)

Summary

- 1) Ground measurements are the main datasets for validation of snow water equivalent data products.
 - The biggest challenge is the low spatial resolution of passive microwave remote sensing data
 - How to visit the European ground data?
- 2) High resolution remote sensing data are the main datasets for validation of snow cover area data products.
- 3) Inter-comparison is a kind of evaluation for snow cover data products in the stage 3-4.

<p>Stage 1 Validation</p>	<p>Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data.</p>
<p>Stage 2 Validation</p>	<p>Product accuracy is estimated over a significant set of locations and time periods by comparison with reference in situ or other suitable reference data. Spatial and temporal consistency of the product and consistency with similar products has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.</p>
<p>Stage 3 Validation</p>	<p>Uncertainties in the product and its associated structure are well quantified from comparison with reference in situ or other suitable reference data. Uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions. Spatial and temporal consistency of the product and with similar products has been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.</p>
<p>Stage 4 Validation</p>	<p>Validation results for stage 3 are systematically updated when new product versions are released and as the time-series expands.</p>