SMOS
-
CRYOSPHERE

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Atelier Altimétrie, Glaciologie, Juin 2015

SMOS Mission

- Soil Moisture and Ocean Salinity

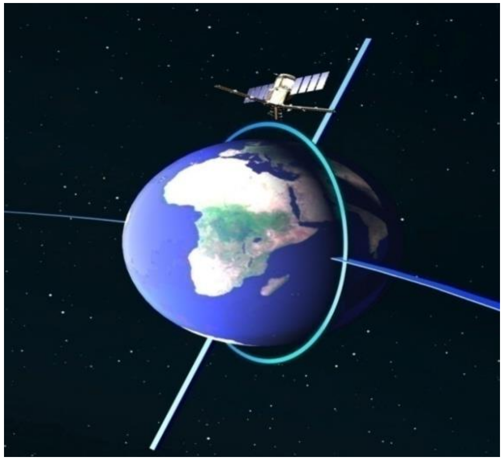
- Fréquence = 1.4 GHz, λ = 21 cm
  - Domaine spectral des micro-ondes, bande L
  - Mesures de surface (0-3/5cm)

- Instrument : interferomètre 2 D, passif

- Résolution instrument ~43 km en moyenne
  Reconstruction d'image permet d'avoir des cartes à des résolution de 15km et 25 km

- Résolution temporelle
  Surface terrestre couverte entirement en 3 jours
  Orbite ascendante : 6 a.m., heure solaire locale
  Orbite descendante : 6 p.m., heure solaire locale

- Durée :
  Lancement nov. 2009
  Données depuis printemps 2010

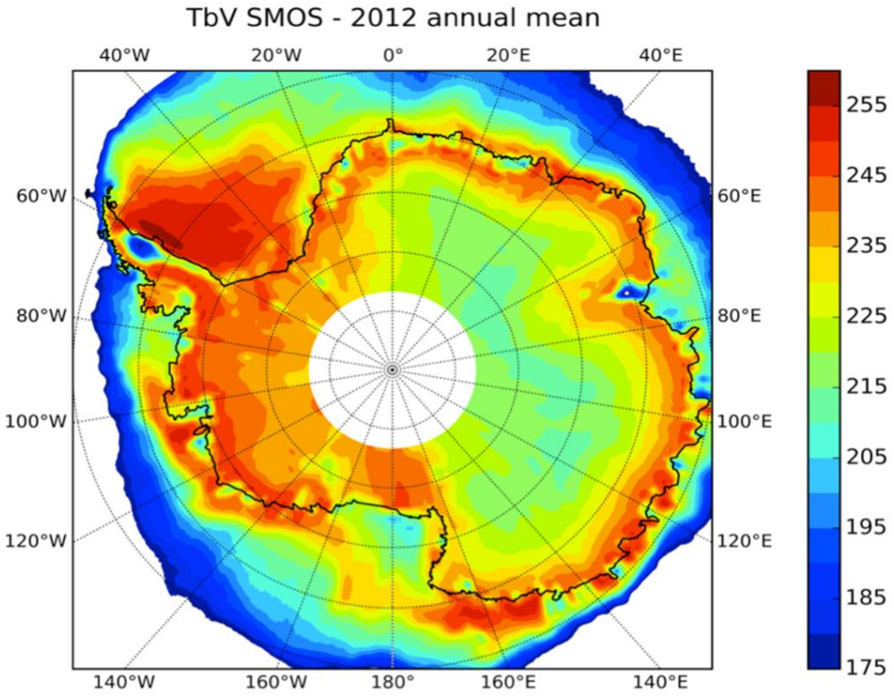


SMOS Mission

Objectifs principaux de la mission SMOS

i) Contenu en eau de la surface
ii) Salinité des océans

Second objectif : **cryopshère**

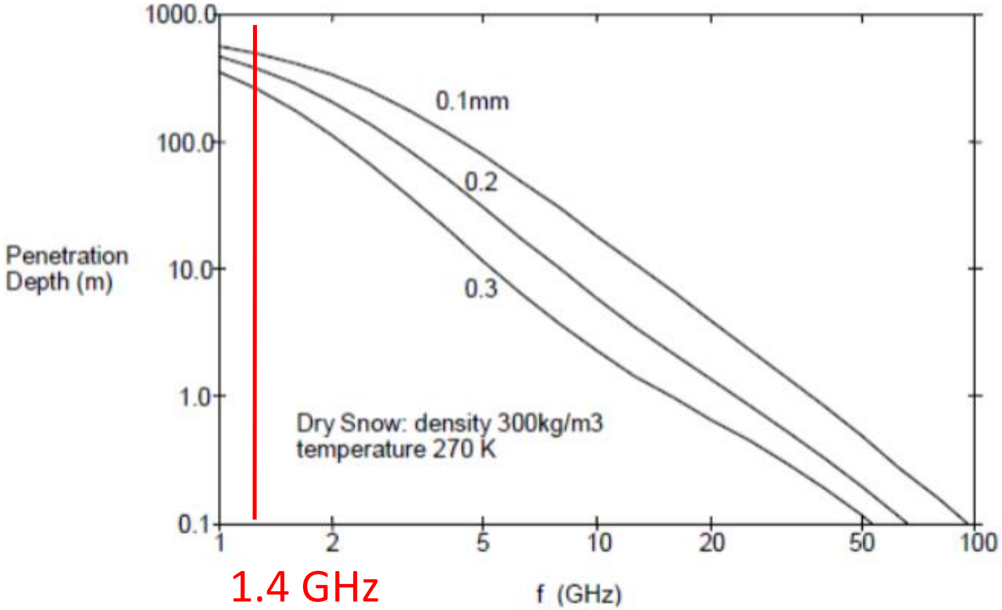


<u>But de la présentation</u> :

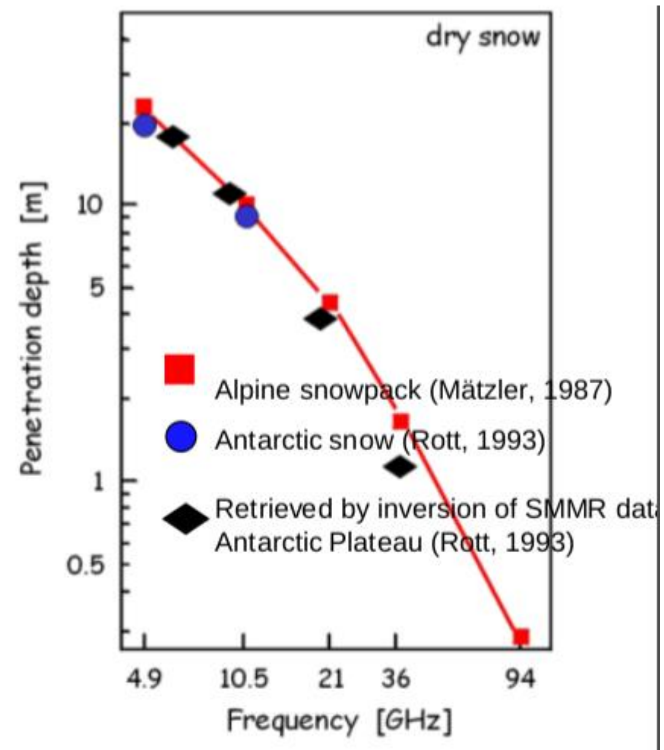
Montrer quelques projets autour de l'utilisation de SMOS pour les régions polaires

SMOS Mission

- Couverture temporelle et spatiale : les hautes latitudes sont couvertes en 2 jours
- Prof. Pénétration : complémentaire aux satellites existants



Penetration depth (by Matzler)



Cryosmos Project: Exploiting the Potential of SMOS Data in Antarctica

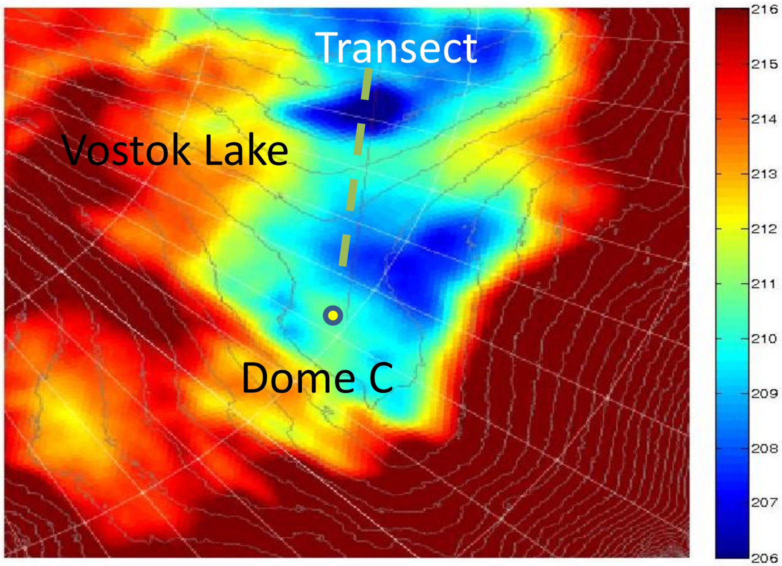
G. Macelloni [1], M. Brogioni [1], N. Skou [2], R. Forsberg [2], G. Picard [3], M. Leduc-Leballeur [3], L. Kaleschke [4], A. Wernecke[4], A. Mialon [5], Y. Kerr [5], O. Gråbak [6]

- Projet ESA (Agence Spatiale Européenne)
- 2 ans, début Nov. 2014
- Etudier le potentiel des données SMOS sur l'Antarctique
- 4 cas d'études

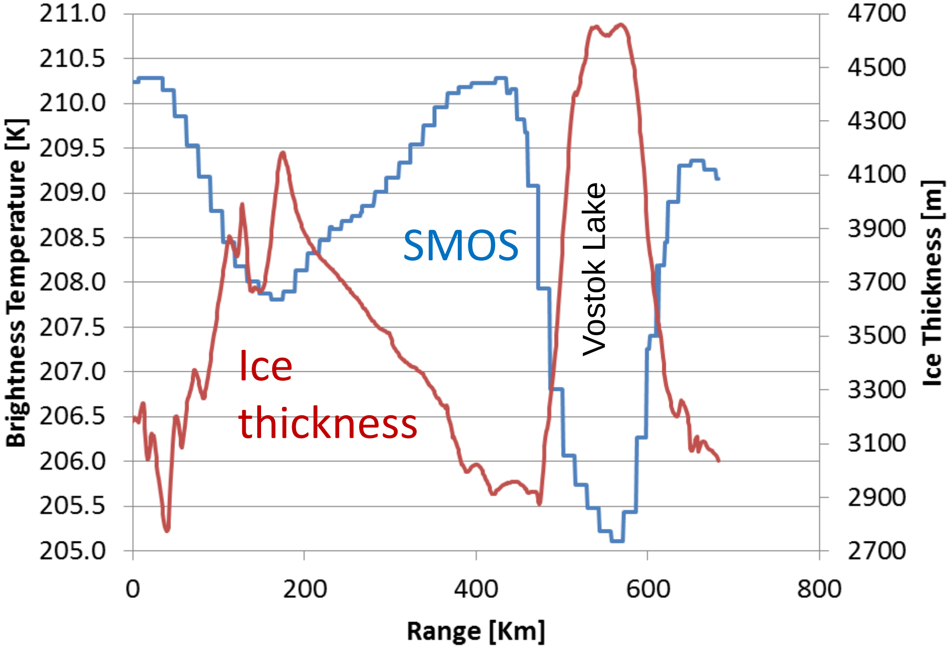
[1] 1 CNR (Italy), [2] DTU (Denmark), [3] LGGE (France), [4] University of Hamburgh (Germany), [5] CESBIO (France), [6] ESA/ESRIN (Italy)

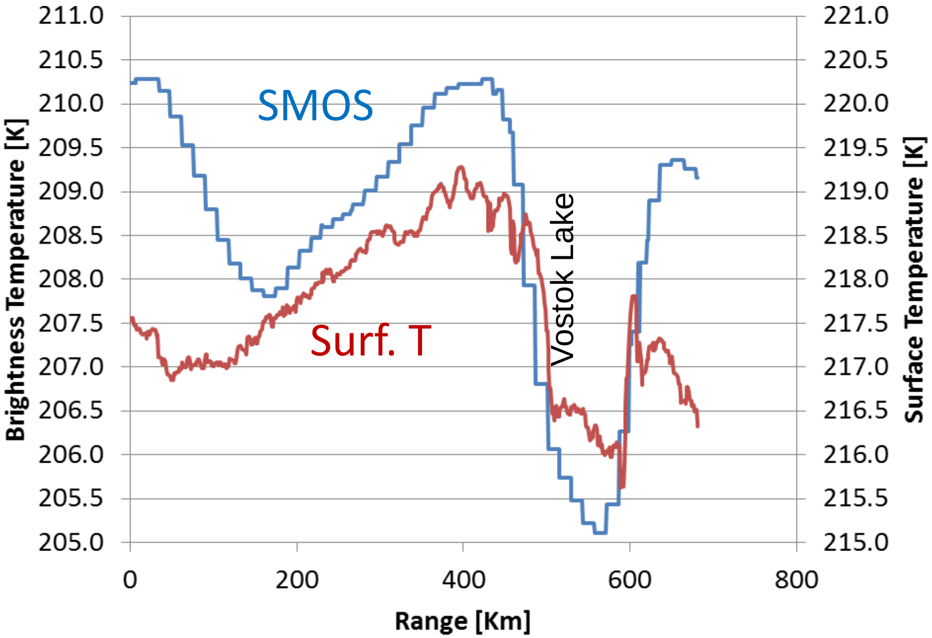
Cryosmos, cas d'étude 1: quantifier la température interne de la calotte antarctique

G. Macelloni , M. Brogioni



Température de brillance de SMOS, Plateau Antarctique





Cryosmos, cas d’étude 1: quantifier la température interne de la calotte antarctique

G. Macelloni , M. Brogioni

ice sheet internal temperature difficult to obtain

SMOS Brightness temperatures depend on the ice temperature profile,
which in turn depends directly on surface temperature and inversely on ice thickness
(besides other factors like geothermal heat flux, accumulation rate and advection)

By using E.M. models, ancillary data and glaciological models the project aims at developing a retrieval algorithm for the ice temperature estimation

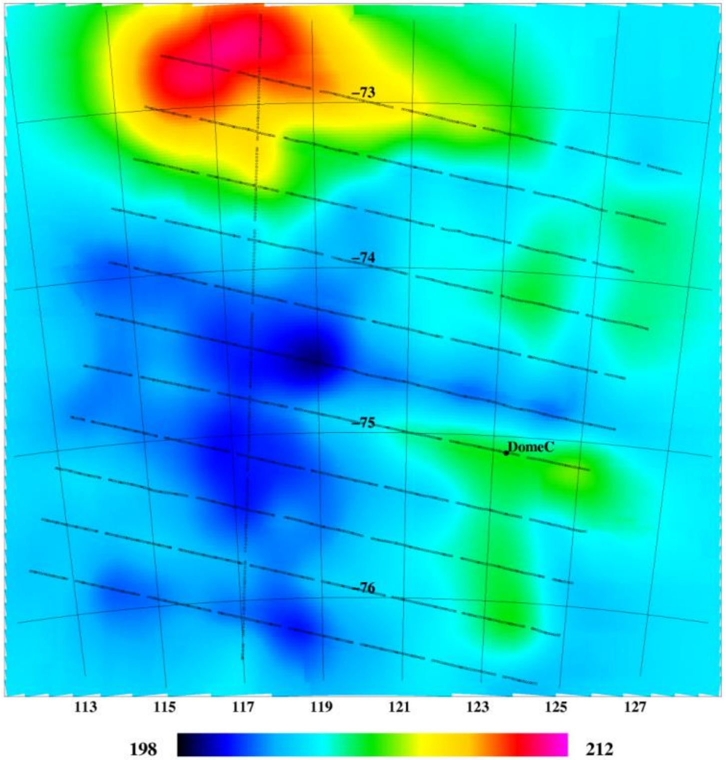
The cal/val of the algorithm will be performed inland where ground truth is available and then extended to other regions

Cryosmos, case d'étude 2 : bedrock topography and/or geothermal heat flux

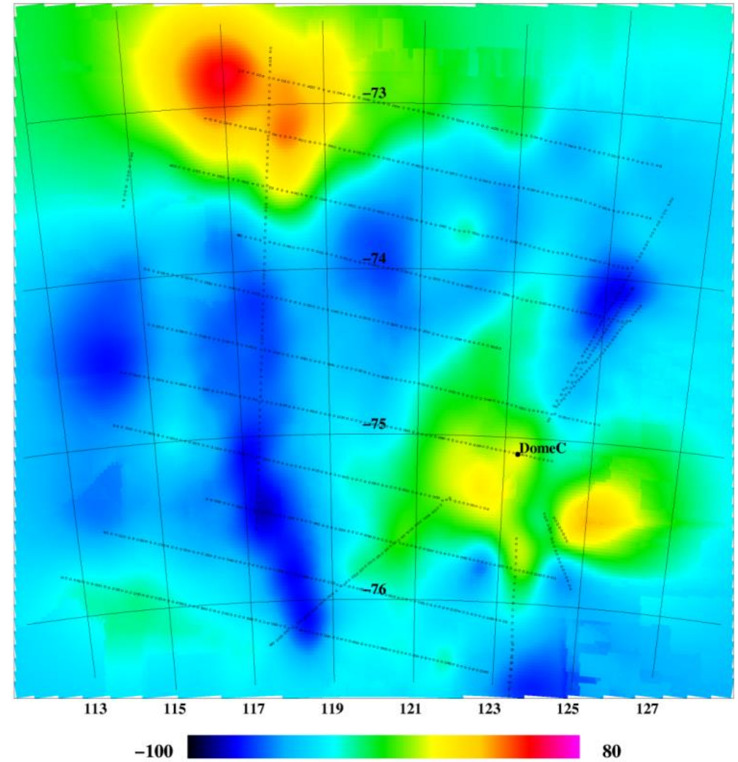
N. Skou

- In January 2013 the DOMECair airborne campaign took place at Dome C with the aim of characterizing the brightness temperature and the gravimetry of the region (350 km x 350 km)
- The analysis of DOMECair datasets revealed a convincing correlation between Tb and gravimetric data, and between Tb and bedrock elevation
- These findings open up the possibility of using SMOS data for estimating the subglacial terrain characteristics at large scale where even the best maps can have appreciable uncertainties
- The first step of the work will be focused on the Dome C region where high resolution Tb data are available as well as bedrock maps from Radio Echo Soundings mainly obtained from Ground Penetrating Radar

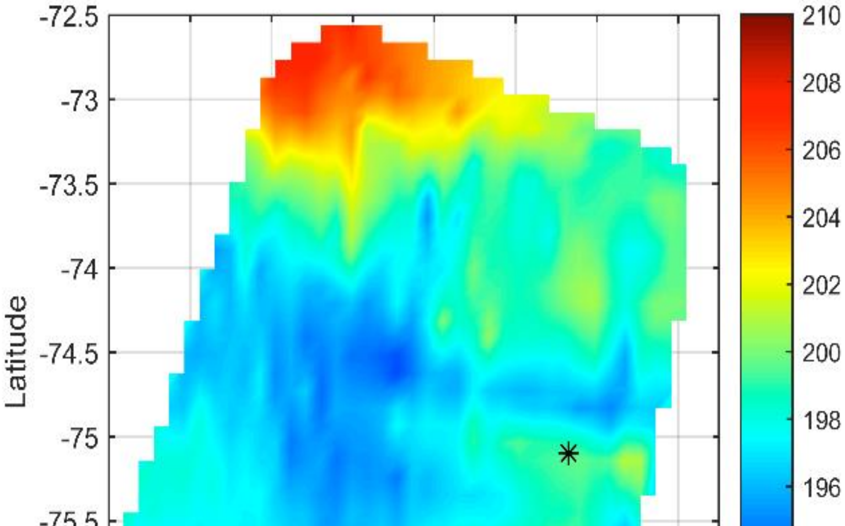
Domecair Tb nadir



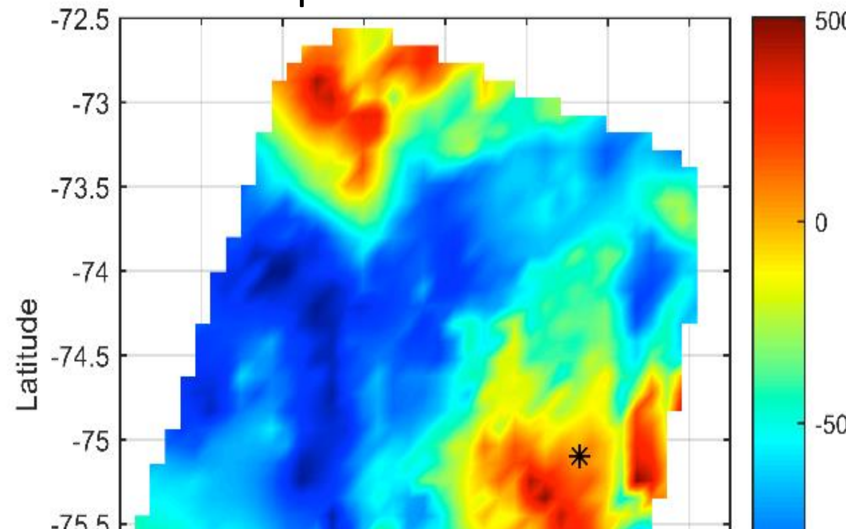
Gravimetry



Domecair Tb nadir



Bedmap2

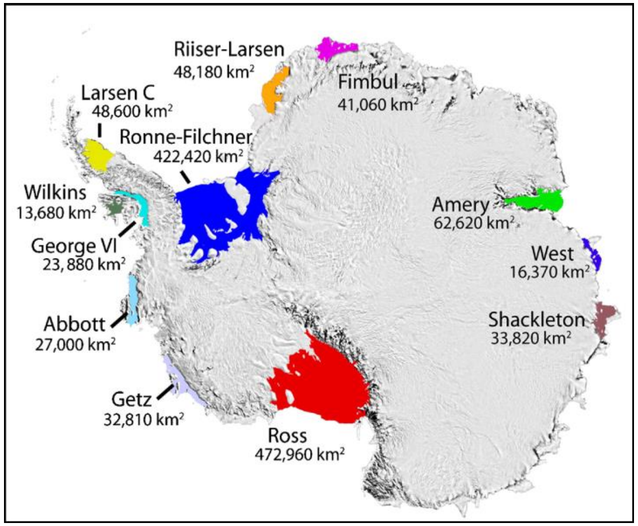


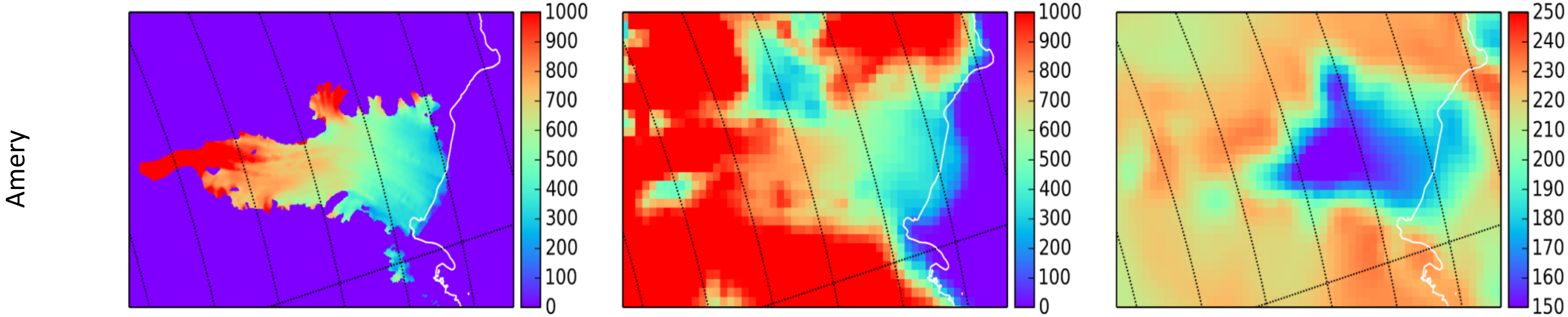
Cryosmos, cas d’étude 3: characterization of ice shelves

L. Kaleschke

The project aim is to study the possibility for the retrieval of mainly three geophysical parameters which are of high importance for the ice shelf stability:

- the internal ice temperature
- the shelf ice thickness
- the detection of basal marine ice





Thickness
Deeporter et al 2013

Thickness
Rtopo

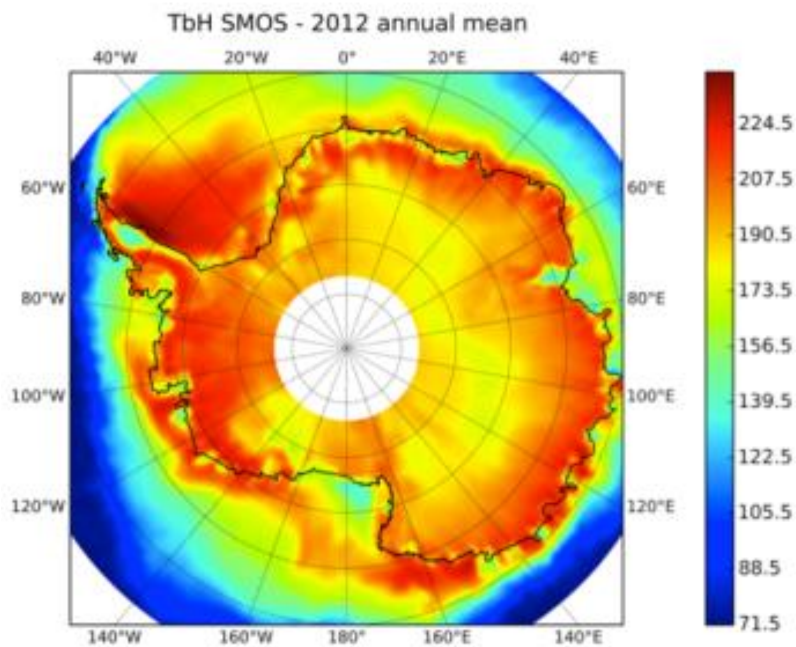
SMOS Tb

Cryosmos , cas d'étude 4: processus de surface

G. Picard , M. Leduc-Leballeur ,

- SMOS observations could help to detect surface state variations: e.g. snowfalls in order to give information about precipitations, variations of roughness linked to wind, onset and duration of melting periods.
- Thanks its large penetration depth, SMOS observations could detect if melt is deep and impacts snowpack stability
- In the internal part of continent (ice sheet is always dry) L-band Tb is very stable and small variations observed could be interpreted like changes in surface state
- Along the coast and on ice-shelves (wet snow area) surface state is affected by seasonal melting events and SMOS observations could help to follow and characterize them

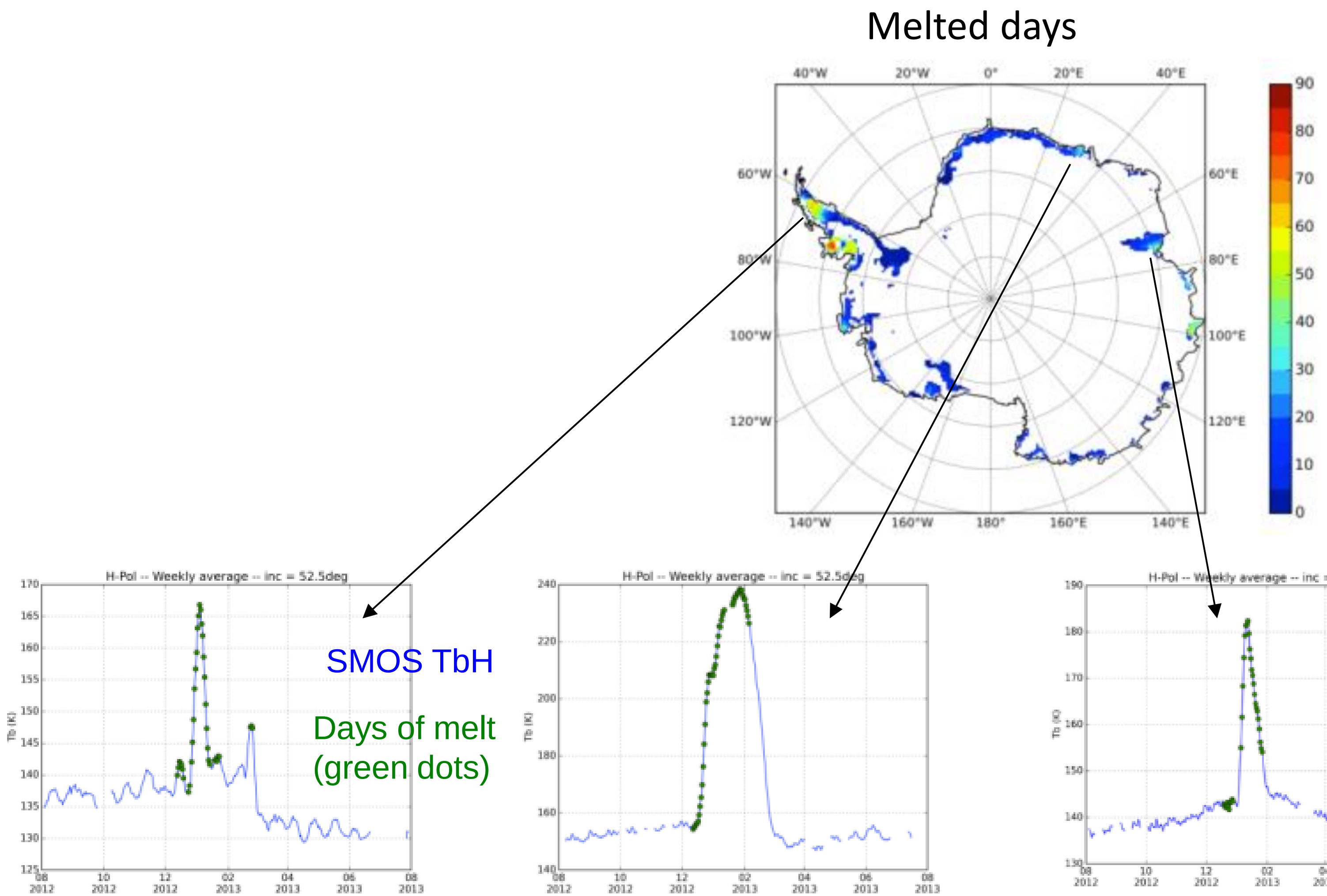
Température de brillance SMOS



Cryosmos , cas d'étude n.4: processus de surface

G. Picard , M. Leduc-Leballeur

i) Wet Snow effect on Tb



Coastal area: SMOS observations affect by seasonal melting events

Cryosmos , cas d'étude n.4: characterization of surface processes

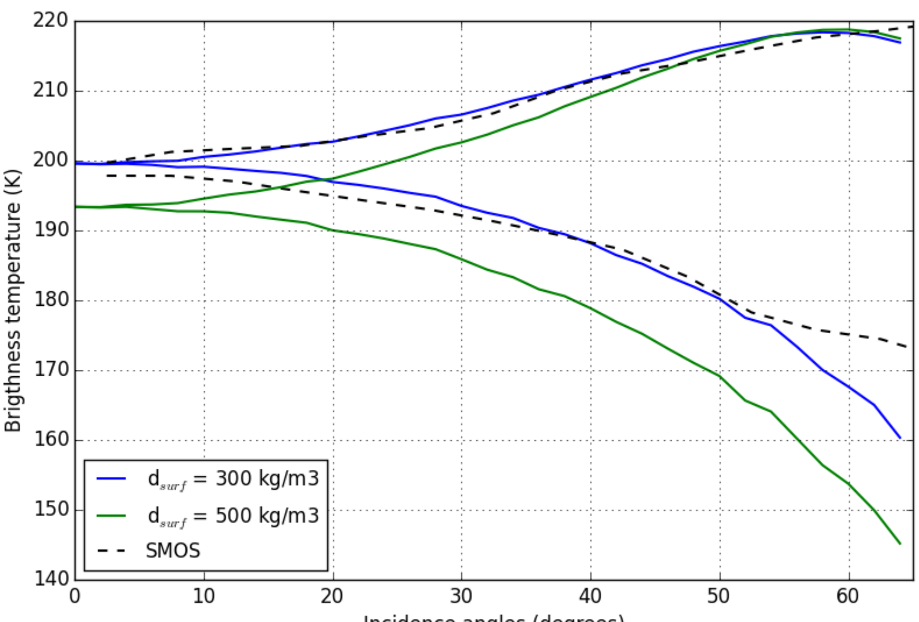
G. Picard , M. Leduc-Leballeur ,

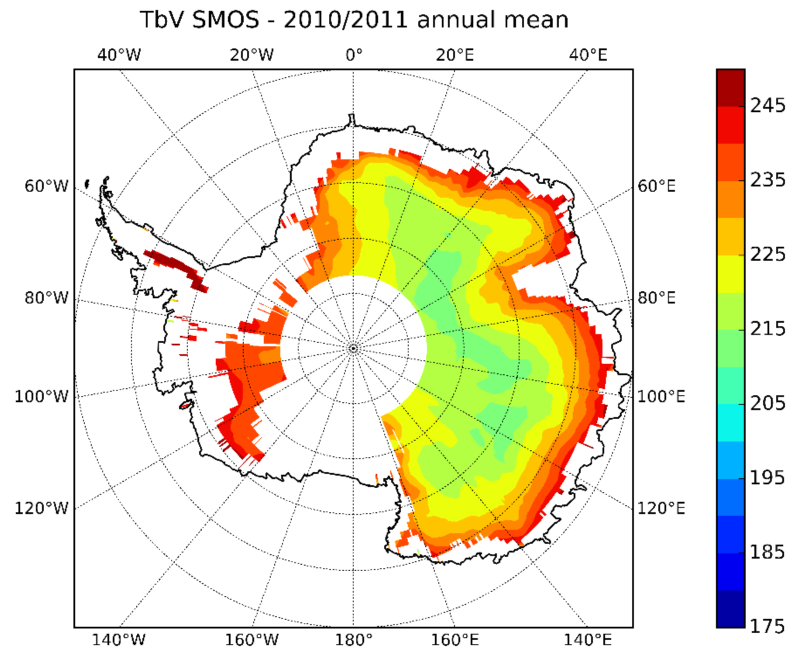
ii) Dry Snow sensitivity to snow density

- Modèle WALOMIS (Leduc-Leballeur et al., 2015) pour simuler l'émissivité en bande L.

- Neige caractérisée par profile de densité (Herron and Langway, 1980) et profiles de températures (Robin, 1964) avec la température de surface ERAI.

- La profondeur de pénétration en bande -L a été estimée à 250m à Dome C





Cryosmos , cas d'étude n.4: processus de surface

G. Picard , M. Leduc-Leballeur ,

ii) Dry Snow sensitivity to snow density

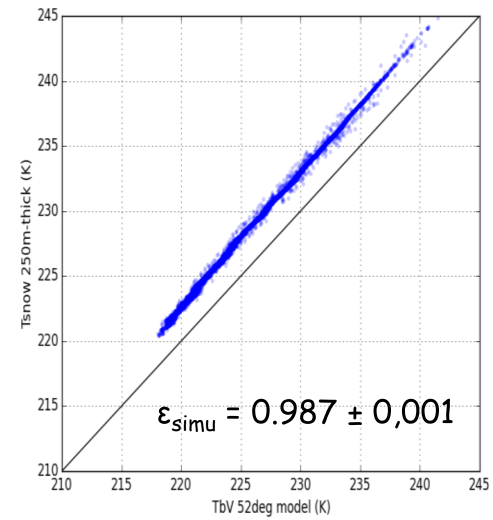
⇒ L-band emissivity is ~ 0.987,
⇒ spatial variability is small (std = 0.001)

TbV_{SMOS} / ε_{simu} = 219.85 K

Measured at Dome C : 219.31 K

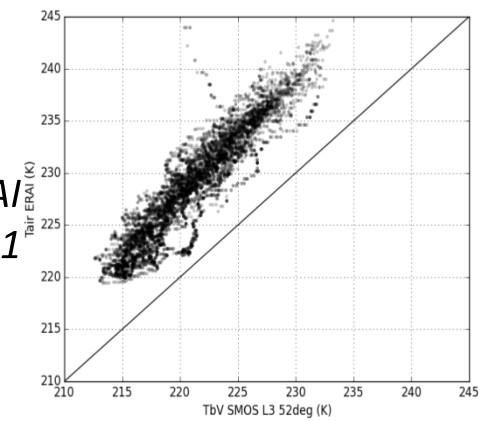
Dome C, Antarctica

mean snow temp. in 250 top meters



Modeled Tb at V polarisation

Tair ERAI Annual mean 2010-11

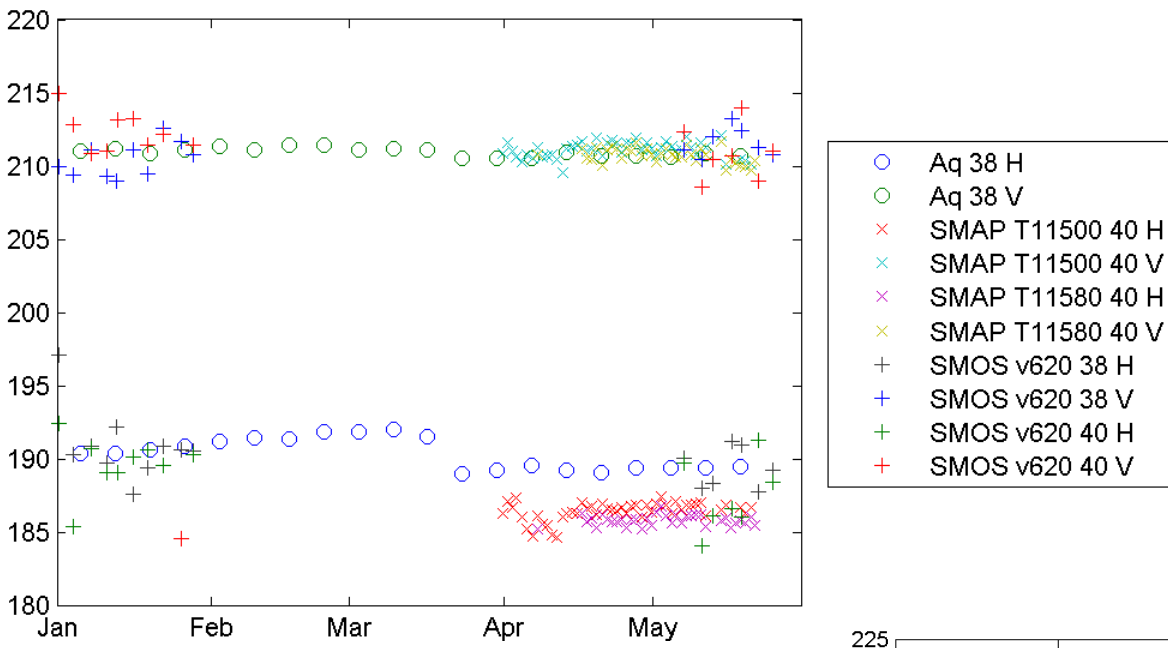


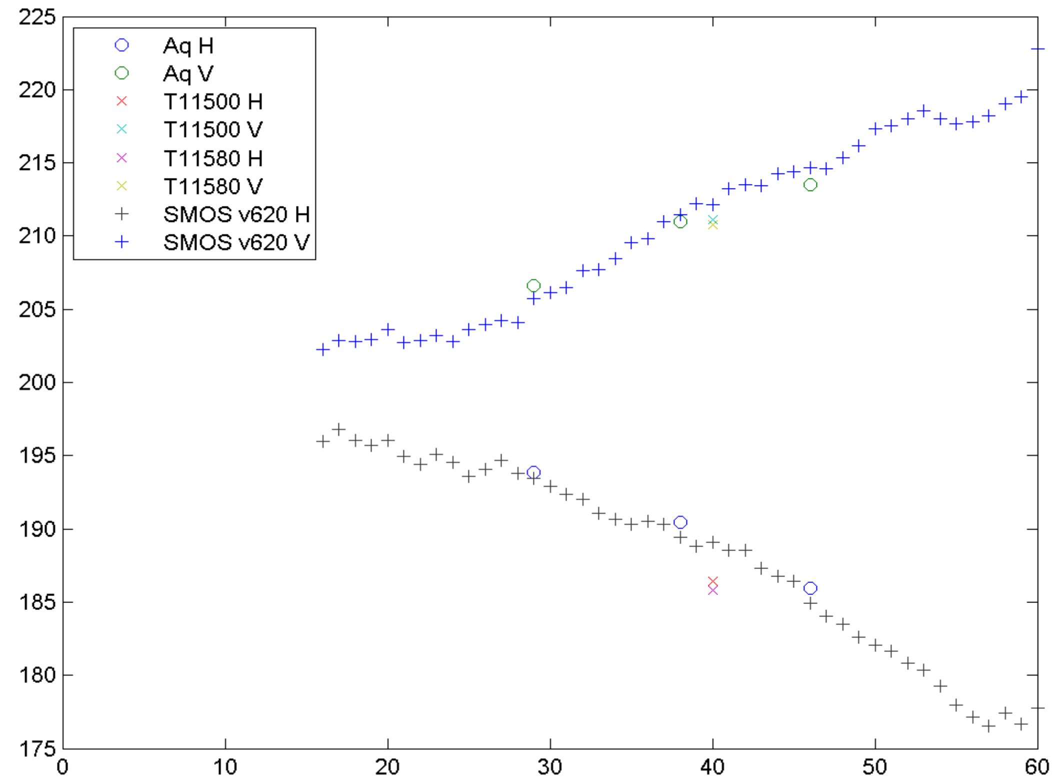
SMOS Tb at V polarisation

Dôme C, Site de Calibration/validation de données SMOS
François Cabot (cesbio)

- Site de Calibration et Validation des données SMOS
- Comparaison avec d'autres satellites Aquarius, SMAP, SMOS
- Radiomètre DomeX *(G.Macelloni)*

Radiomètre
Tour américaine, Dôme C.





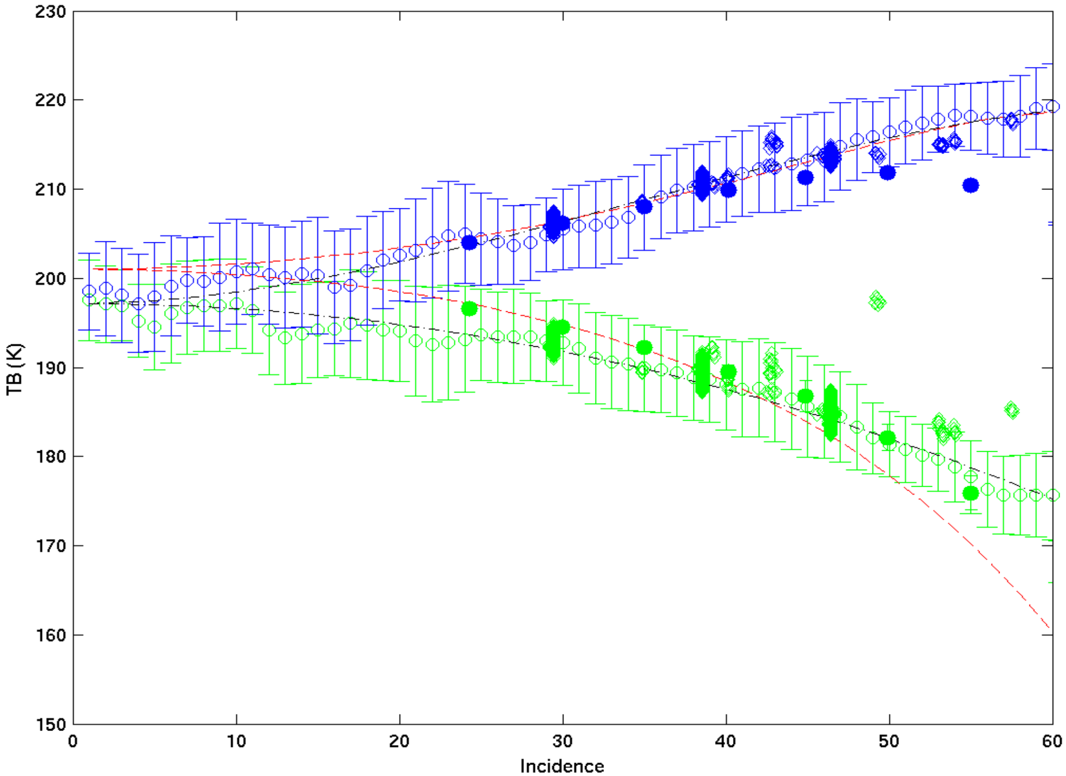
Températures de Brillance

- SMOS
- Aquarius
- SMAP (en phase de recette en vol)

Francois Cabot

Dôme C, Site de Calibration/validation de données SMOS

François Cabot (cesbio)



Incidence Angle

○ ○ SMOS, new release v620

● ● DOMEX Radiometer

◆ ◆ Aquarius

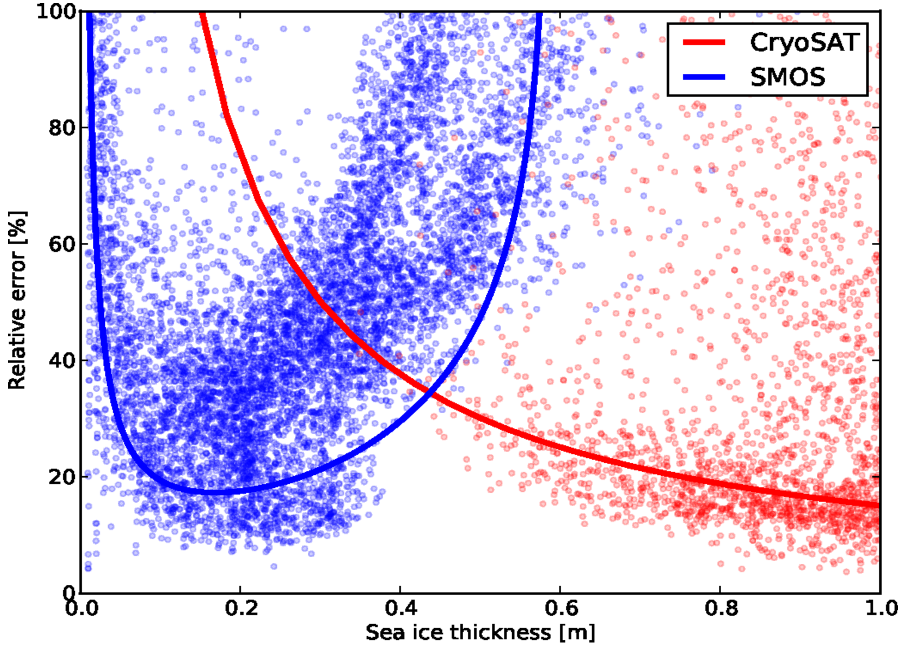
Bias Aquarius-SMOS	
V2.0/V504	V2.7.1/V611
5,71	0,76
6,22	0,29
3,73	0,08
5,16	0,52
4,41	-0,20
5,43	0,23

Bias between SMOS and Aquarius < 1K

Epaisseur de la glace de mer

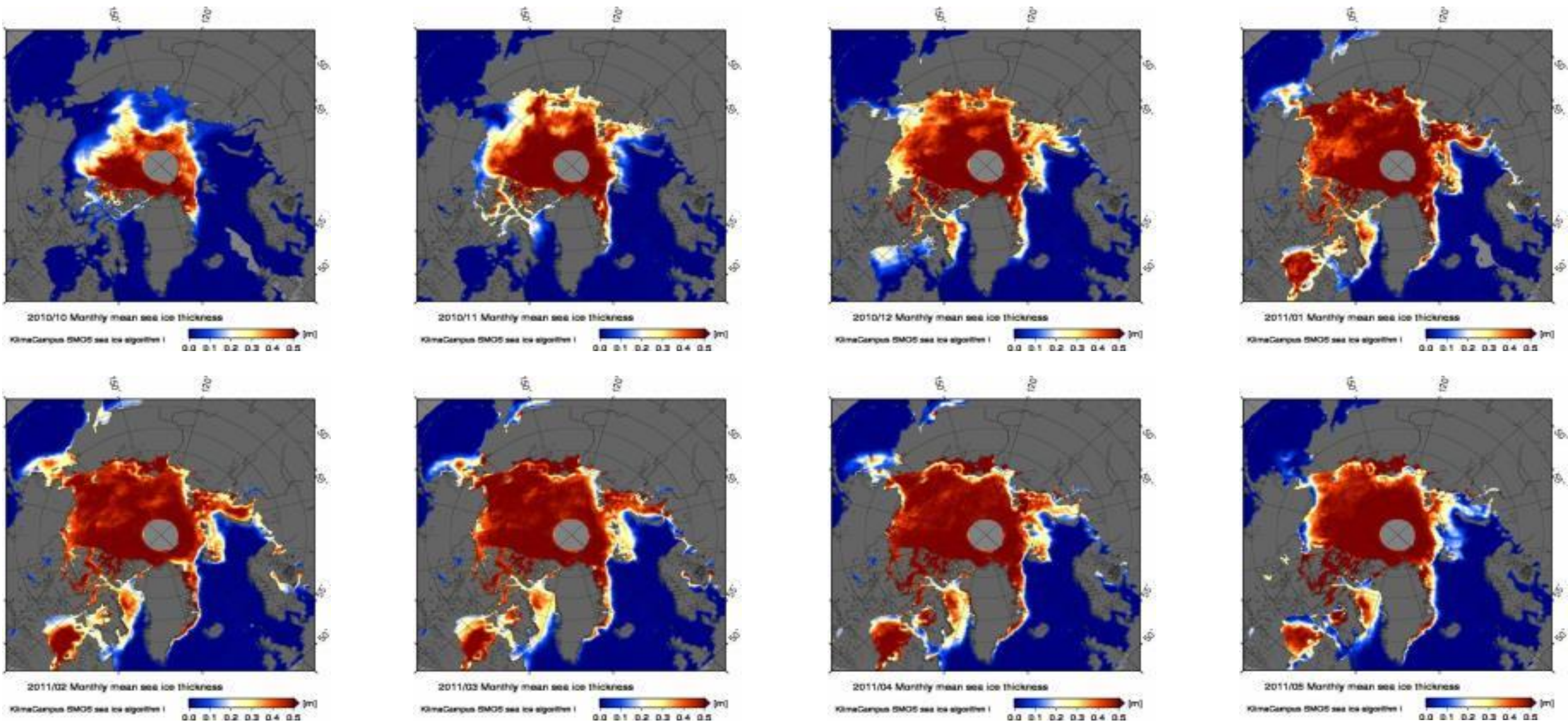
L. Kaleschke (2010, 2012), Xiangshan Tian-Kunze (2014), Maaβ (2013, 2015)

- SMOS Ice : ESA project
- http://icdc.zmaw.de
- Complémentarité des données SMOS et Cryosat pour l'épaisseur de la glace



Epaisseur de la glace de mer

L. Kaleschke (2010, 2012), Xiangshan Tian-Kunze (2014), Maaβ (2013, 2015)



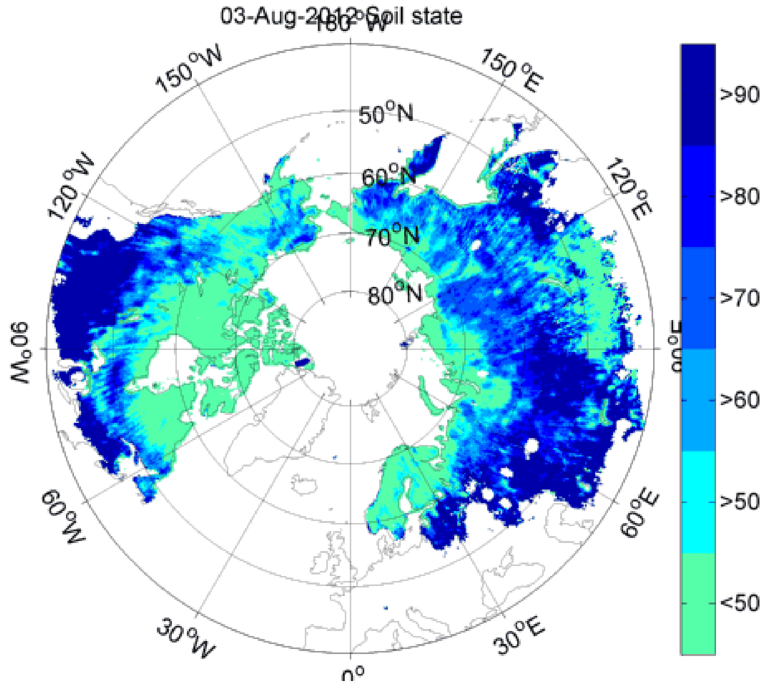
Monitoring and understanding carbon and water cycles at high latitudes using SMOS

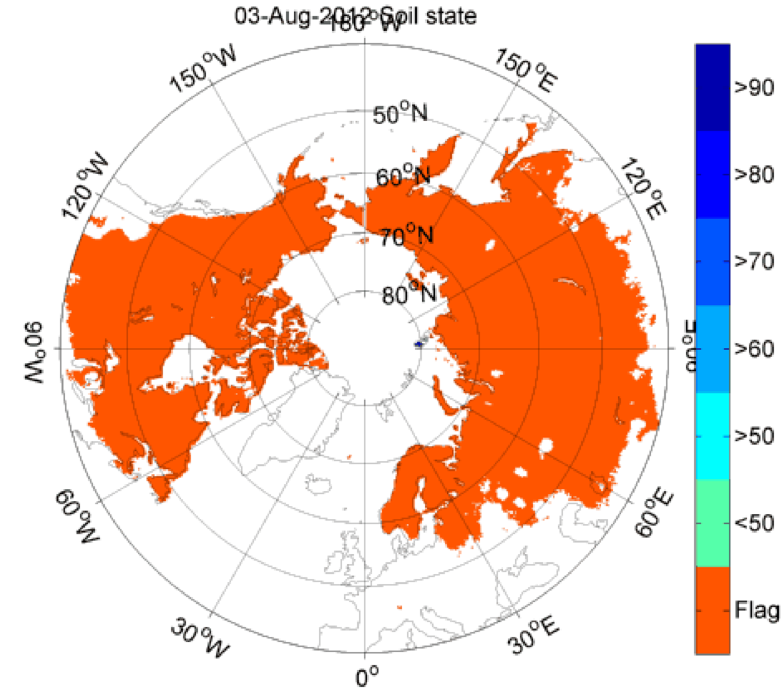
• Objective: to provide a global (Northern Hemisphere) daily soil freeze/thaw product based on SMOS instrument observations

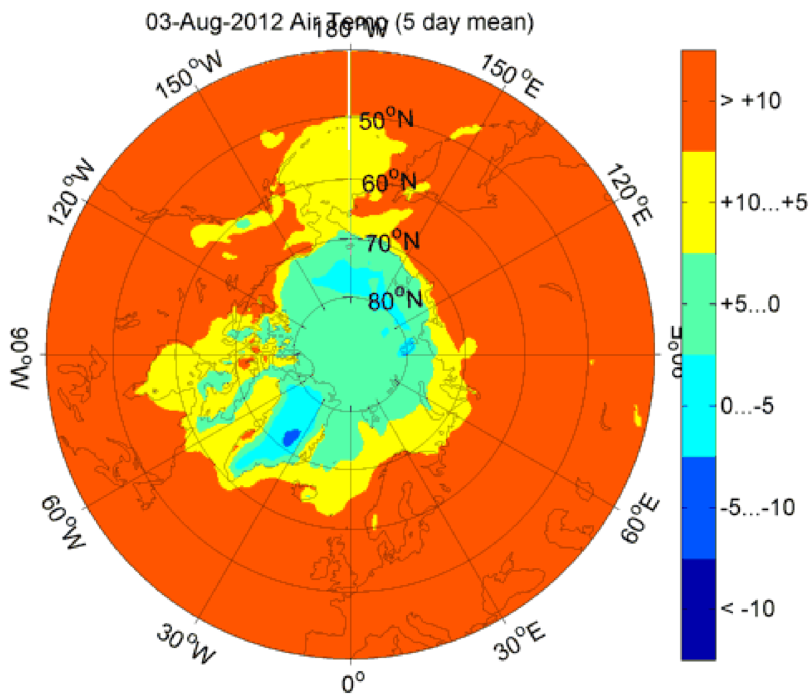
• ESA's SMOS+ Innovation Permafrost and SMOS+ Frost 2 Study –projects
Cooperation with many institutes and organizations: Environment Canada, Cesbio, JPL (SMAP)
Additional in-situ data providers: Finnish Environement Institute, Alfred Wegener Institute, Russian Academy of Science

• *Rautiainen, K., Lemmetyinen, J., Schwank, M., Kontu, A., Ménard, C. B., Mätzler, C., Drusch, M., Wiesmann, A., Ikonen, J., and Pulliainen, J. (2014). Detection of soil freezing from L-band passive microwave observations. Remote Sensing of Environment, Vol. 147, pp. 206-218.*

• *Understanding the Carbon and Water Cycles using SMOS Data and Models CESBIO, Toulouse, France, 13-14 November 2014. Kimmo Rautiainen, Jouni Pulliainen, Mika Aurela, Juha Lemmetyinen Mike Schwank (Gamma Remote Sensing), Chris Derksen, Alan Barr (Environment Canada)*







SMOS F/T product, current version

Top left: Soil state estimate from SMOS data

Top right: Soil state estimate + ECMWF air temperature flag – no frost if T_{AIR} > 0°C (5 days running mean)

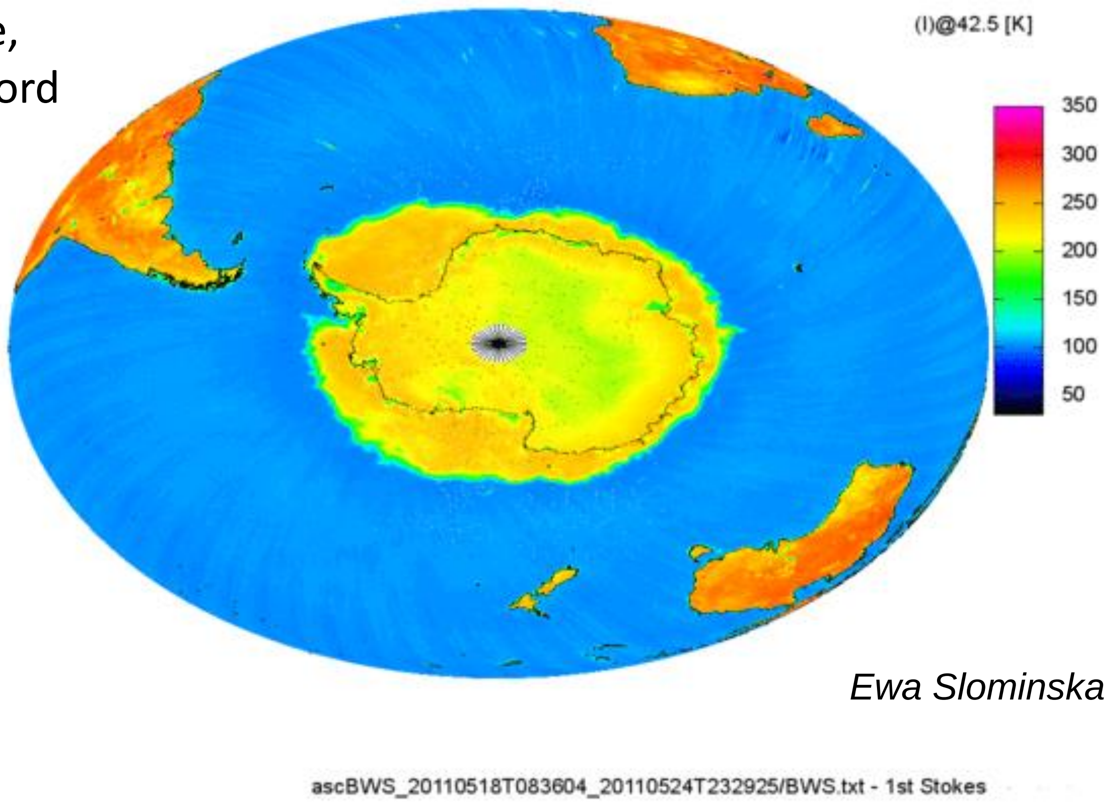
Bottom: ECMWF re-analysis data, 2m air temperature (5 days running mean).

Conclusion

SMOS et la cryosphère …

• Longueur d'onde de 21 cm
Profondeur de pénétration : ~250 m dans la glace
  ⇒ Bon complément aux instruments en vols.
  ⇒ Couverture temporelle et spatiale

• Activités se développent autour de la cryosphère :
  Epaisseur de la glace de mer,
  Densité de la glace en Antarctique,
  Gel du sol des Hautes Latitudes Nord
  …



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