Inclusion of Space-Based Snow Products into the Canadian Land Data Assimilation System

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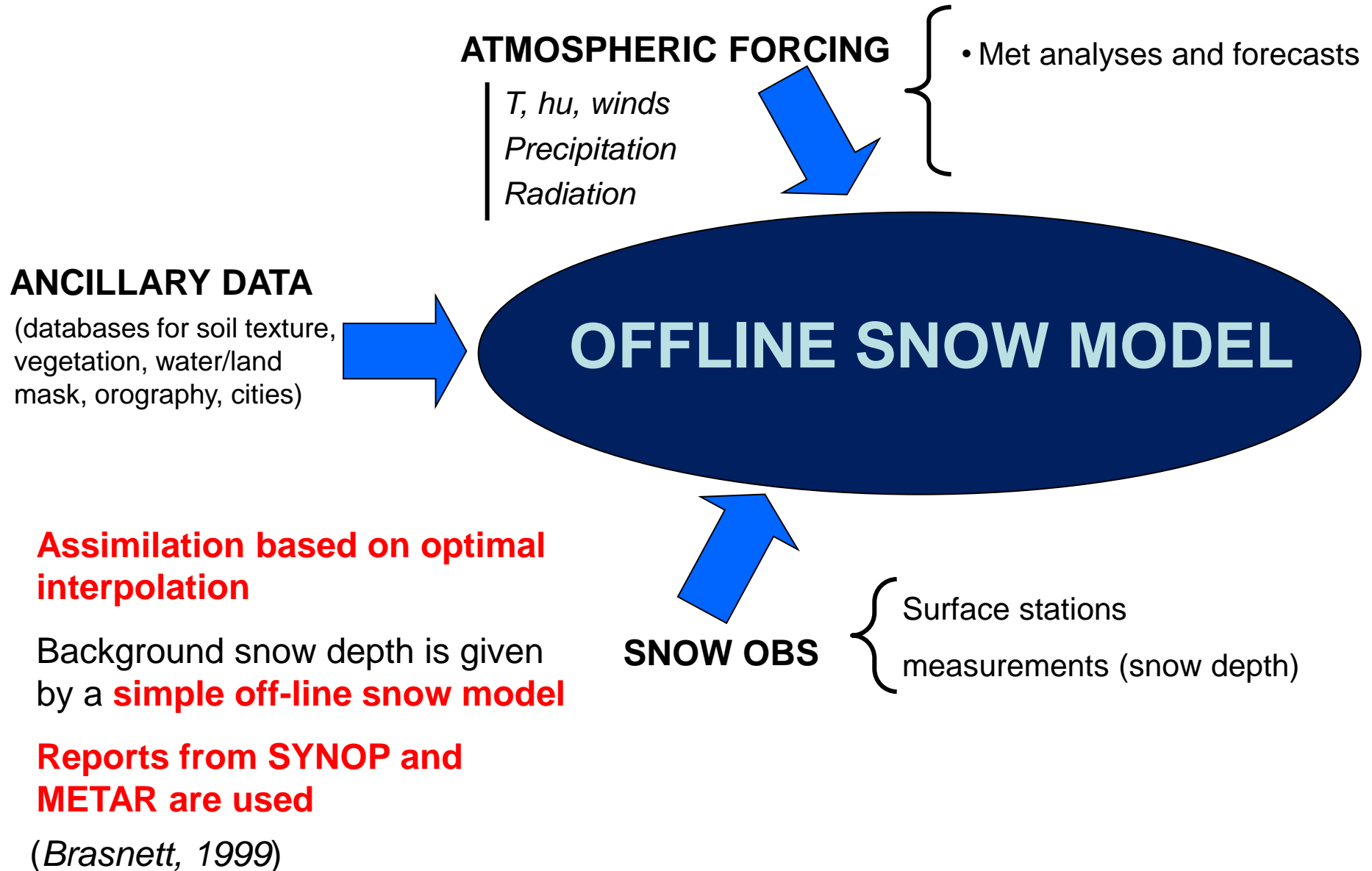*Workshop on European Satellite Snow Monitoring Perspectives, 4-5 Dec. 2012, EUMETSAT*

Snow data assimilation currently operational at EC

ATMOSPHERIC FORCING

T, hu, winds
Precipitation
Radiation

• Met analyses and forecasts

ANCILLARY DATA

(databases for soil texture, vegetation, water/land mask, orography, cities)

OFFLINE SNOW MODEL

Assimilation based on optimal interpolation

Background snow depth is given by a **simple off-line snow model**

Reports from SYNOP and METAR are used

(*Brasnett, 1999*)

SNOW OBS

Surface stations
measurements (snow depth)

The Canadian Land Data Assimilation System (CaLDAS)

IN
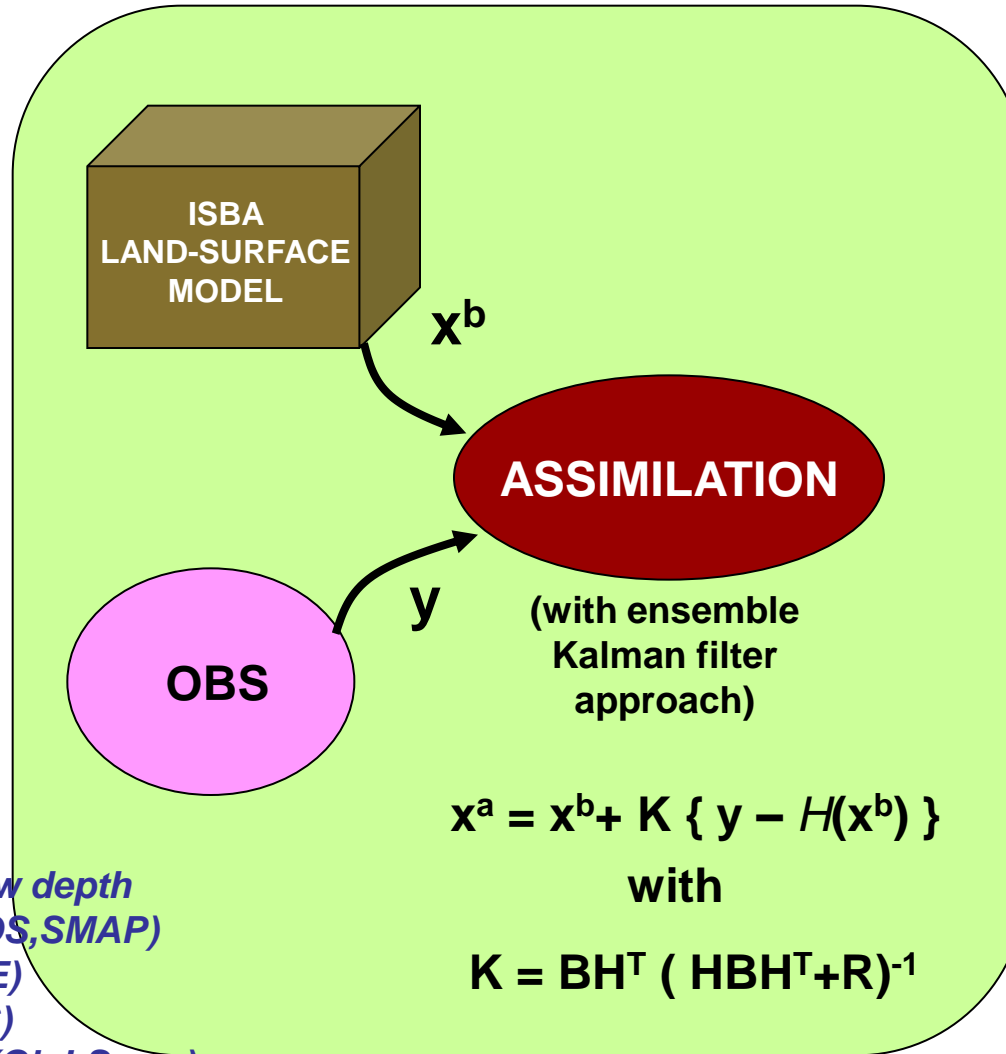
OUT

Ancillary land surface data

Orography, vegetation, soils, water fraction, ...

Atmospheric forcing

T, q, U, V, Pr, SW, LW

Observations

Screen-level (T, Td)
Surface stations snow depth
L-band passive (SMOS,SMAP)
MW passive (AMSR-E)
Multispectral (MODIS)
Combined products (GlobSnow)

ISBA LAND-SURFACE MODEL

x^b

ASSIMILATION

(with ensemble Kalman filter approach)

OBS

y

$$x^a = x^b + K \{ y - H(x^b) \}$$

with

$$K = BH^T (HBH^T + R)^{-1}$$

Land surface initial conditions for NWP and hydro systems (Tsurf, snow, soil moisture)

Land surface conditions for atmospheric assimilation systems

Current state of land surface conditions for other applications (agriculture, drought, ...)

SWE in CaLDAS based on space-based remote sensing: General strategy

Observations: SWE retrievals from AMSR-E or GlobSnow (once a day)

Control variable: snow mass

Other snow variables (snow density and snow albedo) continuously cycled

First guess from ISBA (GEM-Surf)

Number of members: 48

Assimilation step: 6h

AMSRE SWE

Variability relative to filtered (slowly evolving) SWE is used for σ_{obs}

AMSR-E SWE difference raw vs smoothed

Ensemble spread obtained by perturbing the atmospheric forcing, the observations, and the analyses

Observation (random) errors are approximated by the standard deviation of the temporal variability as compared with filtered (slowly evolving) time series

Observation bias (systematic) errors are removed, based on estimates obtained by comparison against surface snow depth observations over a specified area
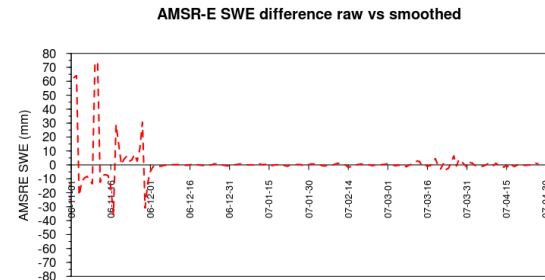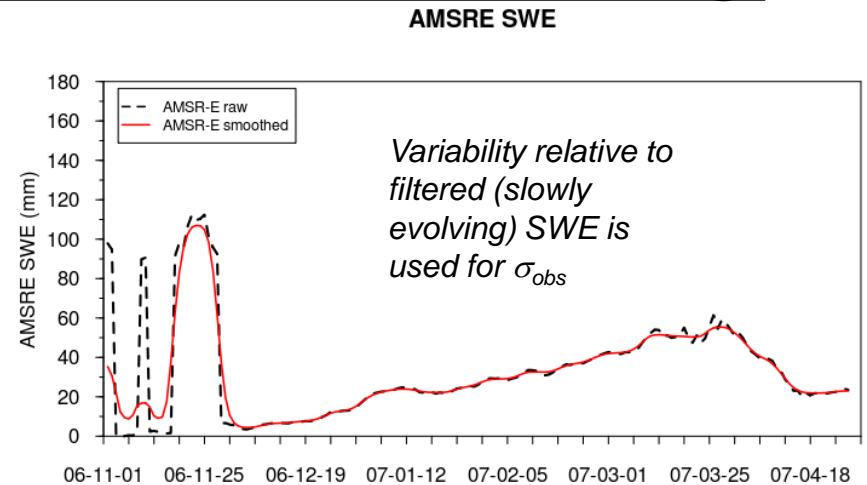
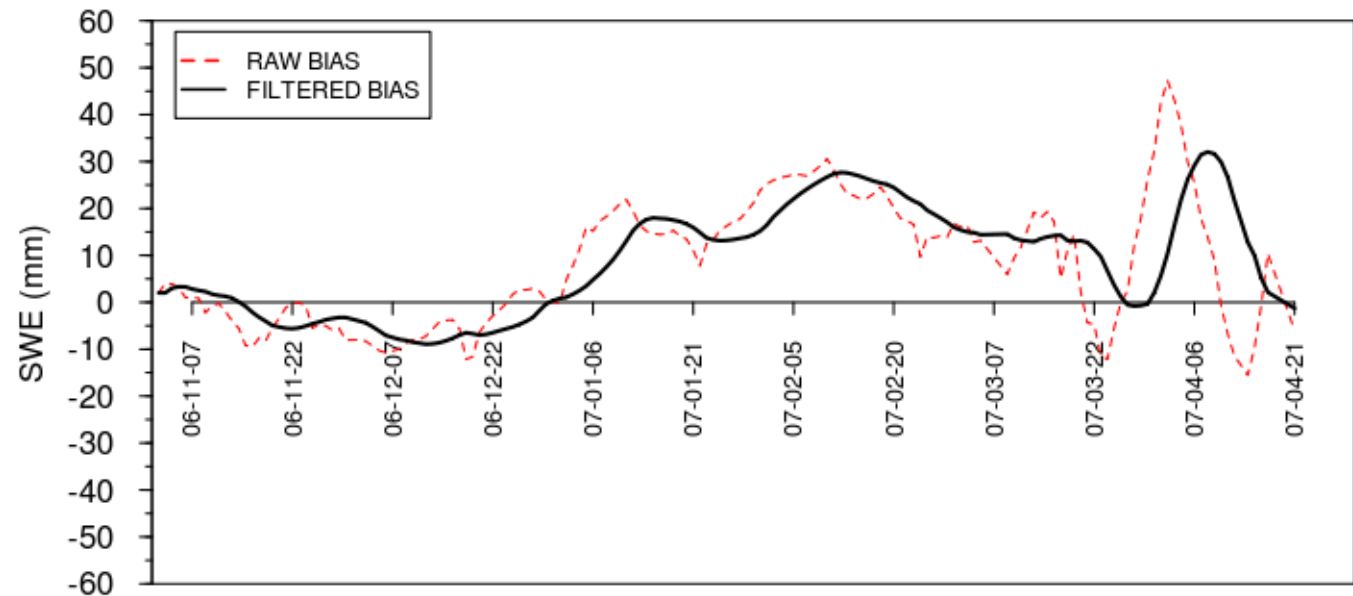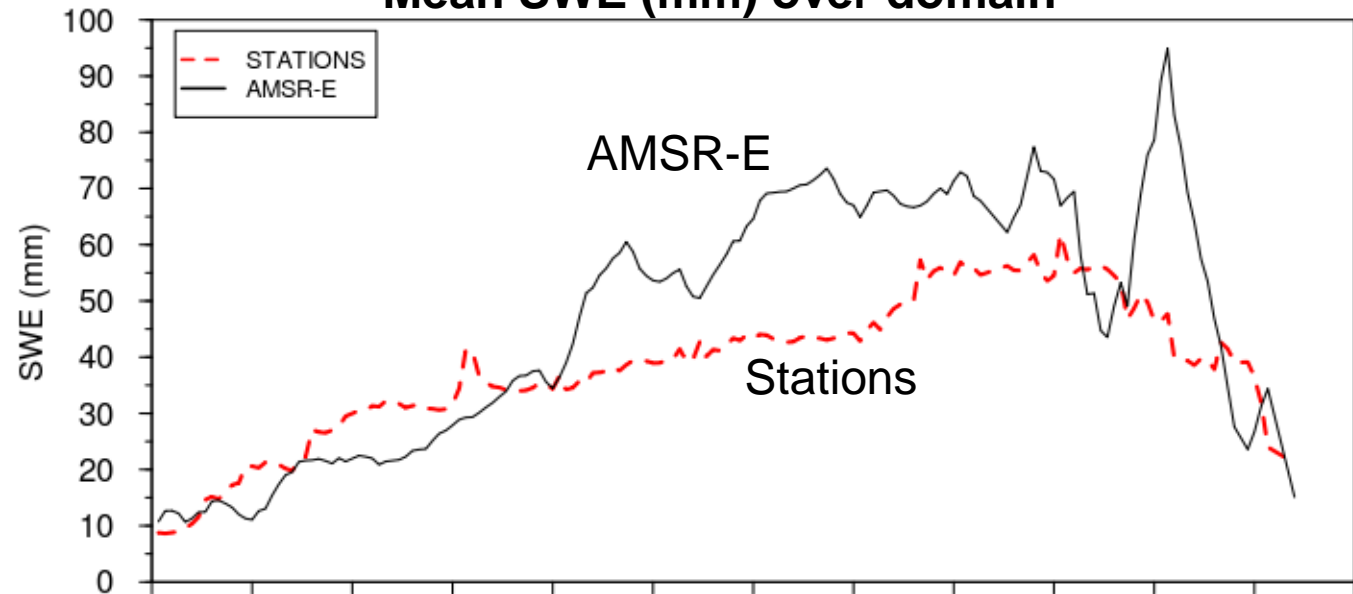# Observation (random) errors for the AMSR-E experiment

AMSR-E SWE observational errors (mm) used in CaLDAS
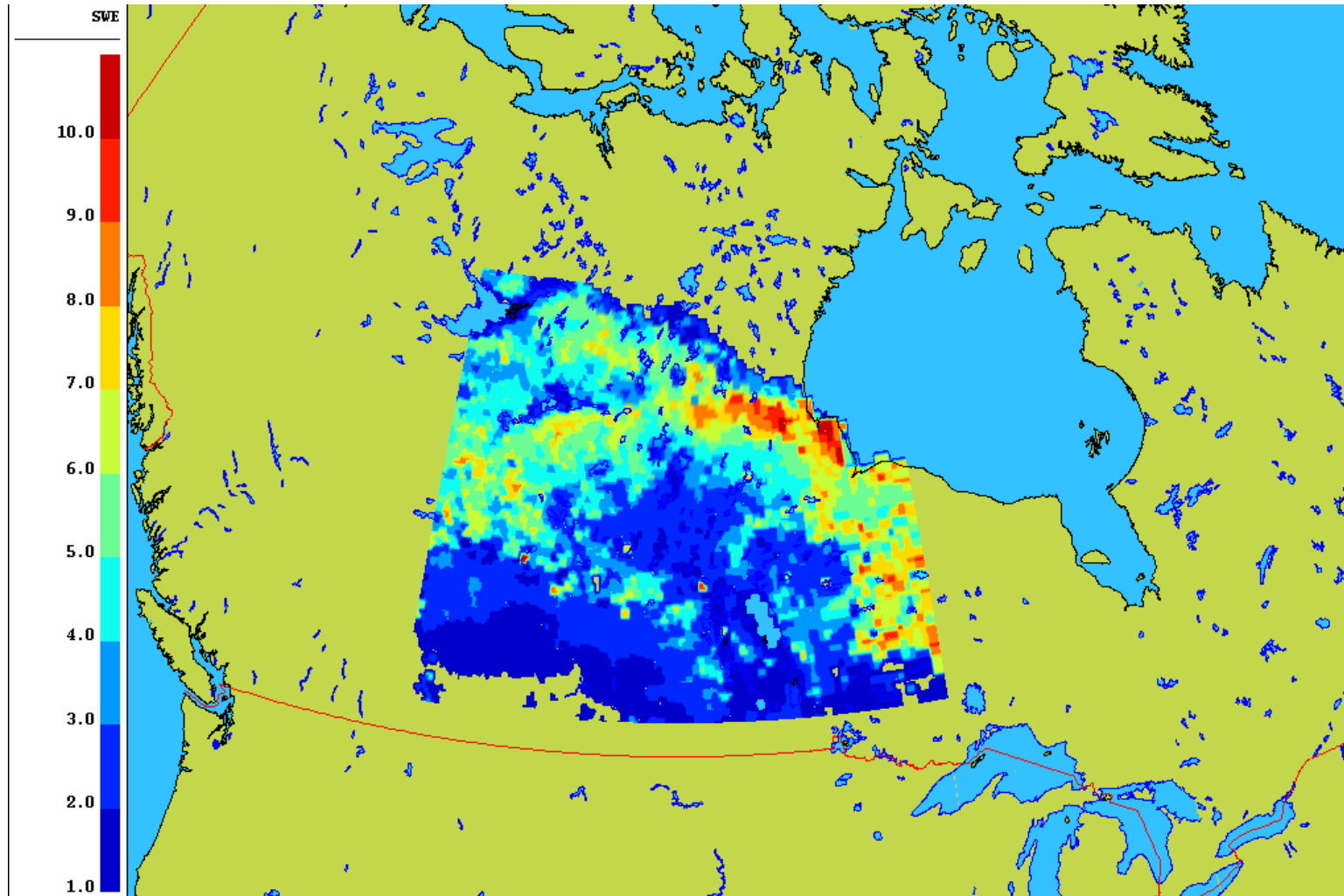
For winter 2006/2007, based on the temporal standard deviation of QA/QC AMSR-E retrievals (EC's algorithms, Derksen et al.) relative to time-filtered (slowly evolving) SWE.

"Bias" (systematic) errors for the AMSR-E experiment
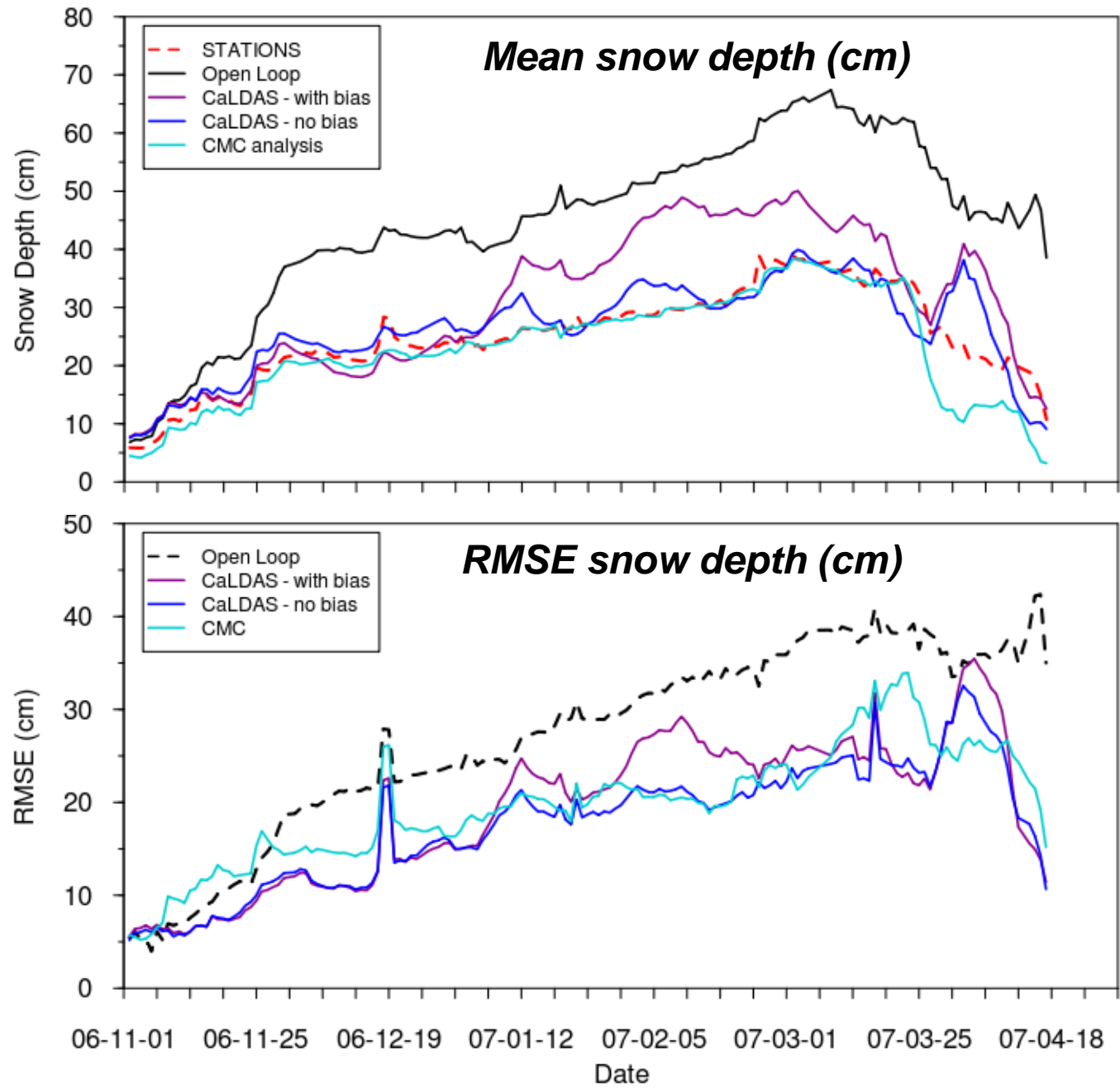
Mean SWE (mm) over domain

Observations from last 10 days (not including current day) are used for bias removal in CaLDAS

Results for the CaLDAS AMSR-E experiment

Bias-removal approach very effective. Main factor in the RMSE differences between the two CaLDAS experiments.

Results different from those previously presented, due to re-examination of the methods used for the objective evaluation.

Mean snow depth (cm)

Legend (top chart):
- STATIONS
- Open Loop
- CaLDAS - with bias
- CaLDAS - no bias
- CMC analysis

RMSE snow depth (cm)

Legend (bottom chart):
- Open Loop
- CaLDAS - with bias
- CaLDAS - no bias
- CMC

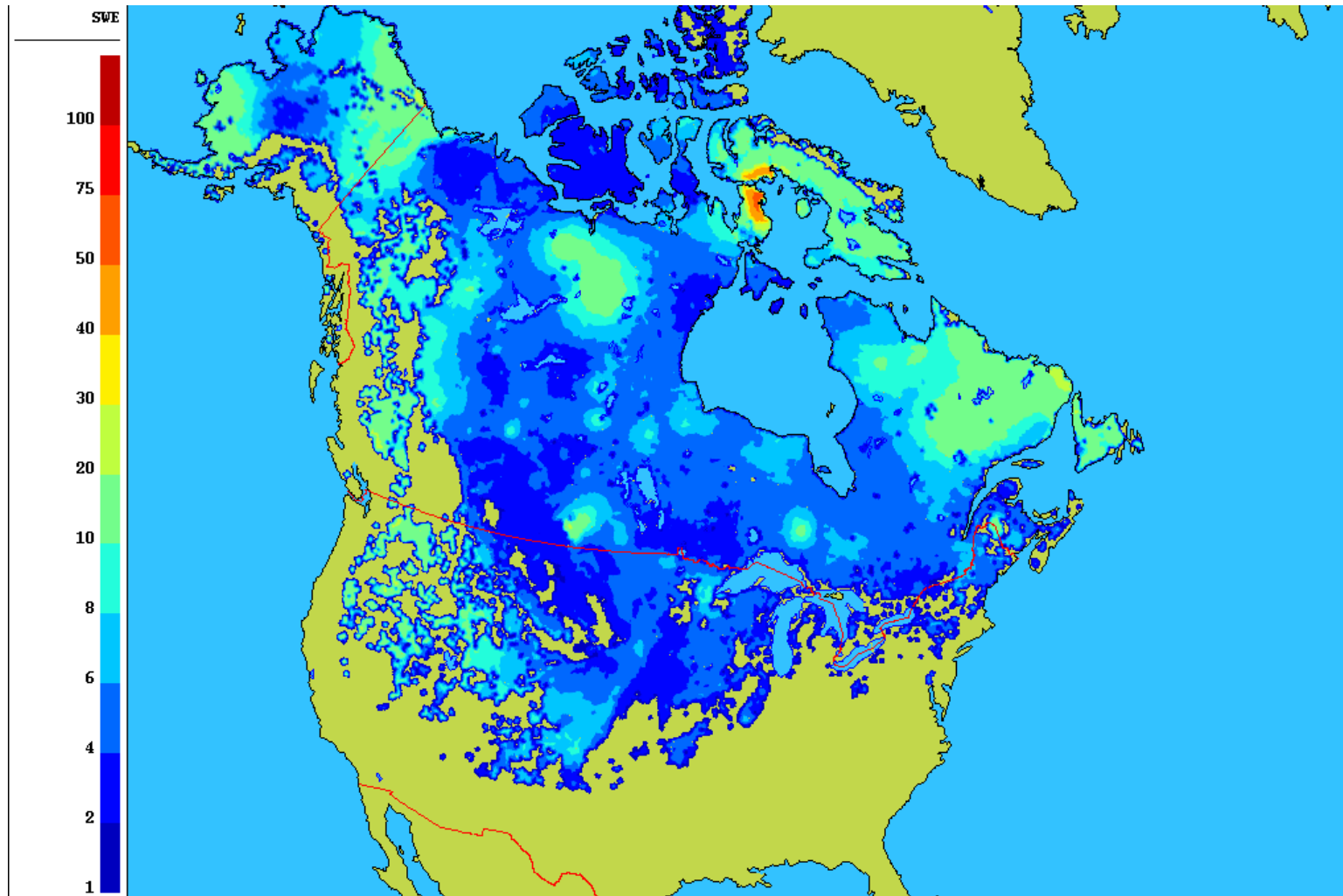# Observation (random) errors for the GlobSnow experiment

GlobSnow SWE observational errors (mm) used in CaLDAS
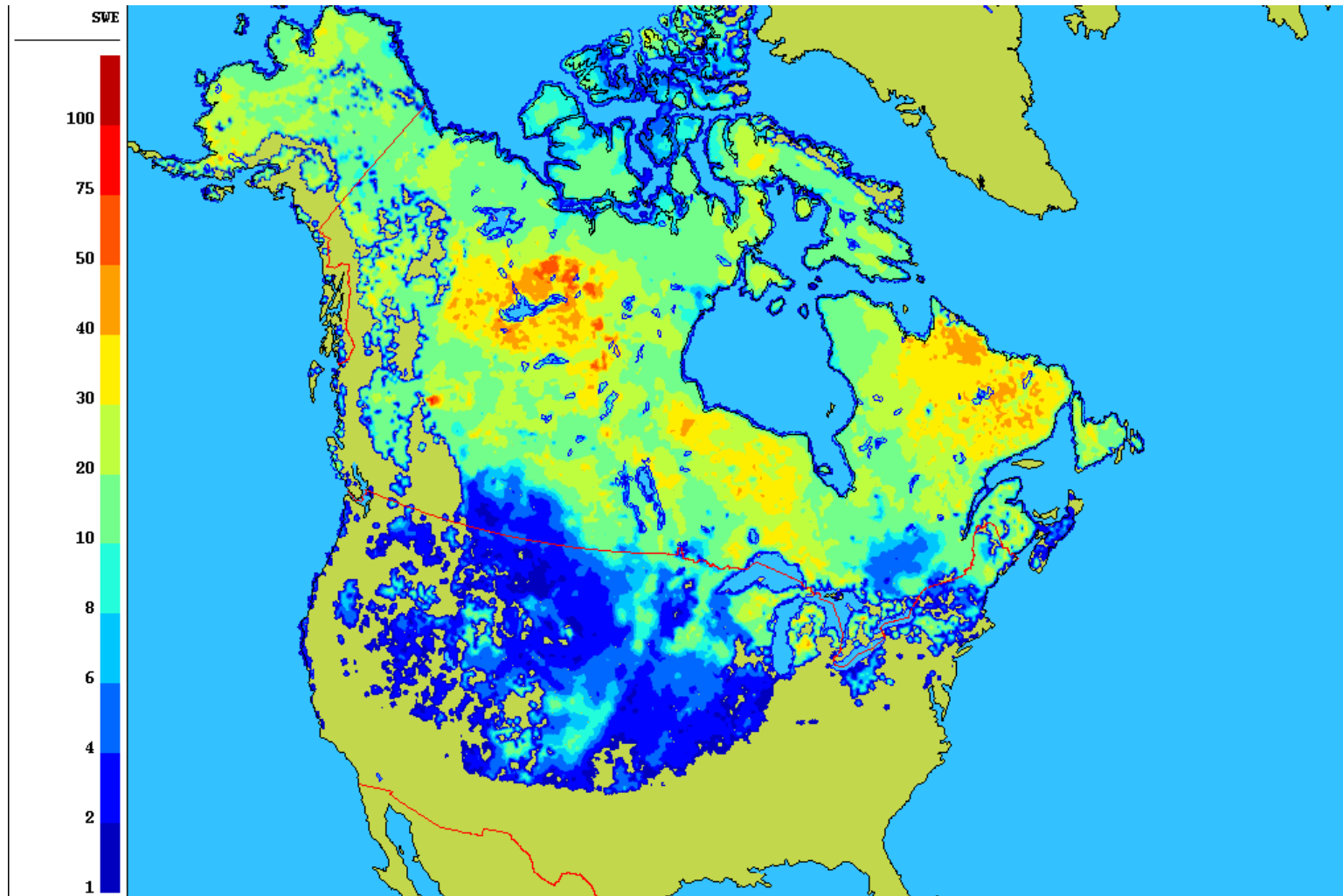
For winter 2006/2007, based on the temporal standard deviation of raw GlobSnow products (not including calibration using surface observations) relative to time-filtered (slowly evolving) SWE.

# Observation (random) errors for the GlobSnow experiment

GlobSnow SWE observational errors (mm) used in CaLDAS

For winter 2006/2007, based on the temporal standard deviation of raw GlobSnow products (<u>this time including calibration using surface observations</u>) relative to time-filtered (slowly evolving) SWE.
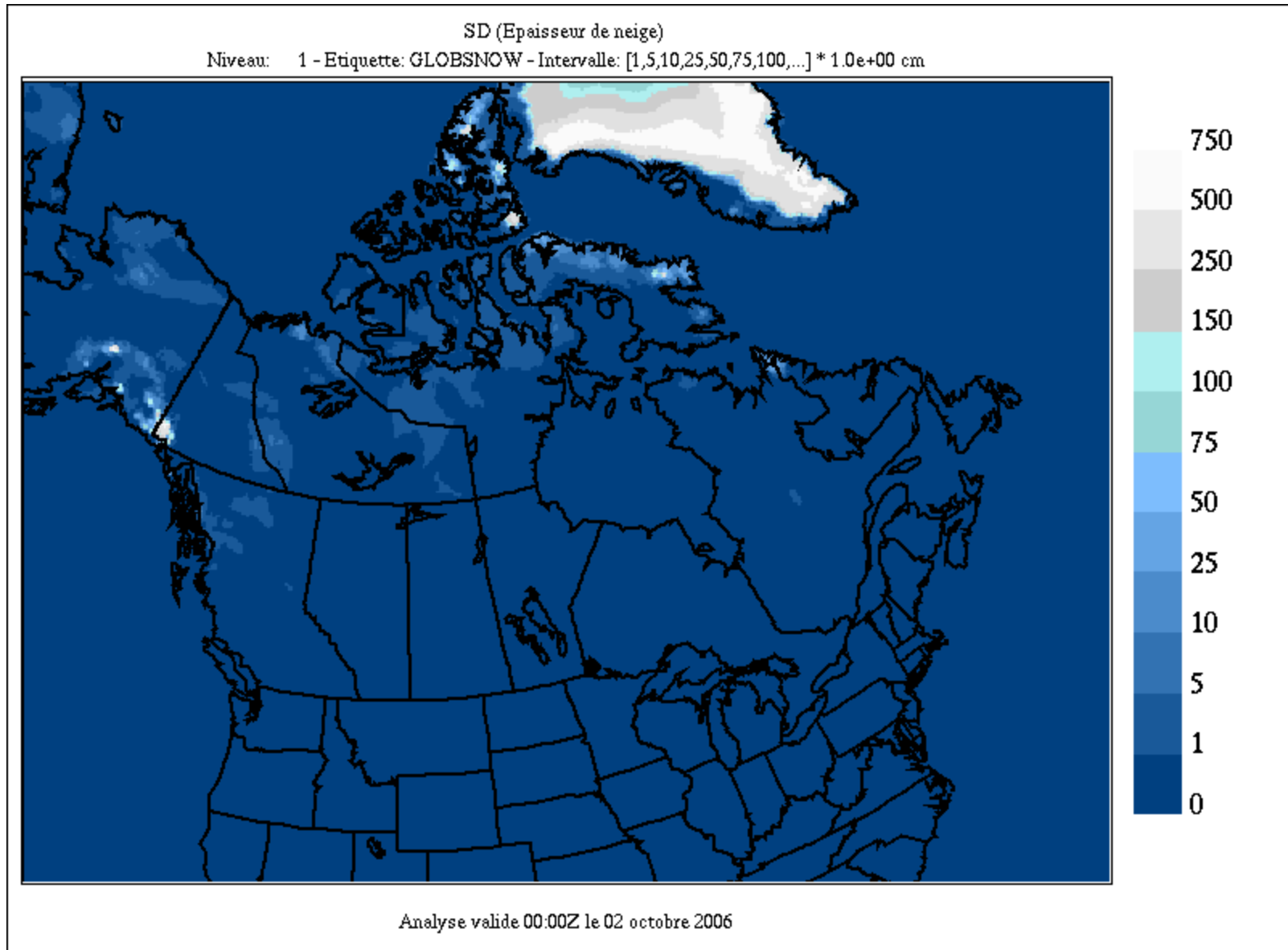
"Bias" (systematic) errors for the GlobSnow experiment

Mean SWE (mm) over domain
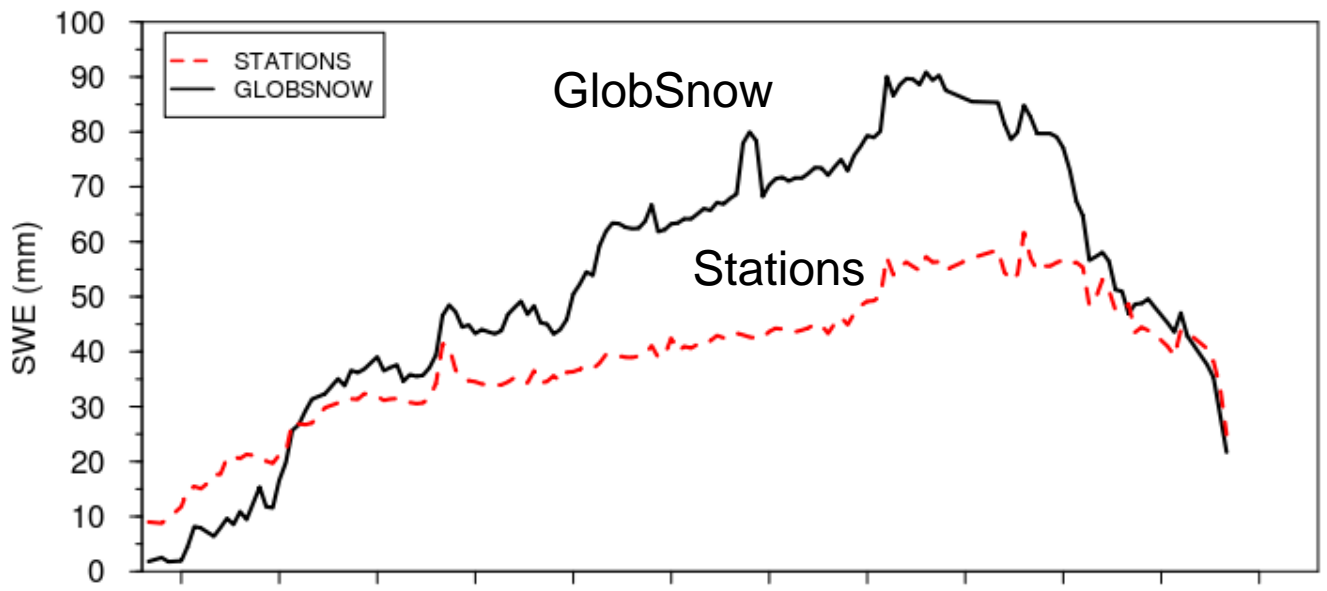
Observations from last 10 days (not including current day) are used for bias removal in CaLDAS
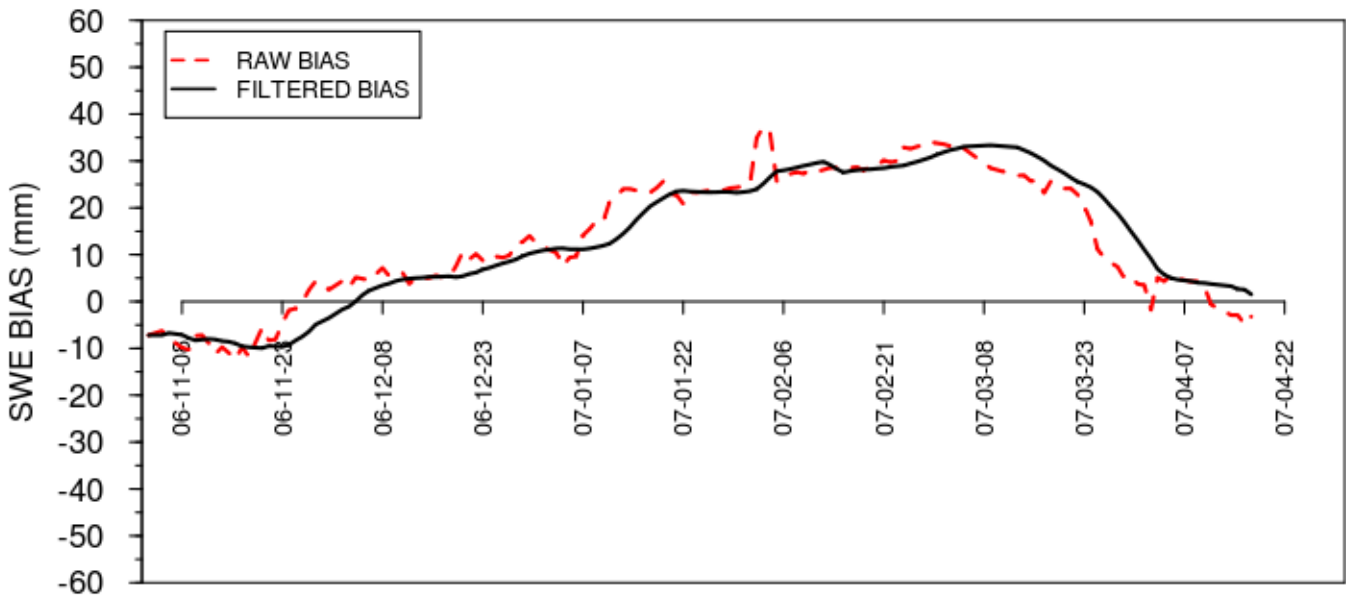
First results for the CaLDAS GlobSnow experiment

2006/2007 CaLDAS-GlobSnow (no surface obs) analyses