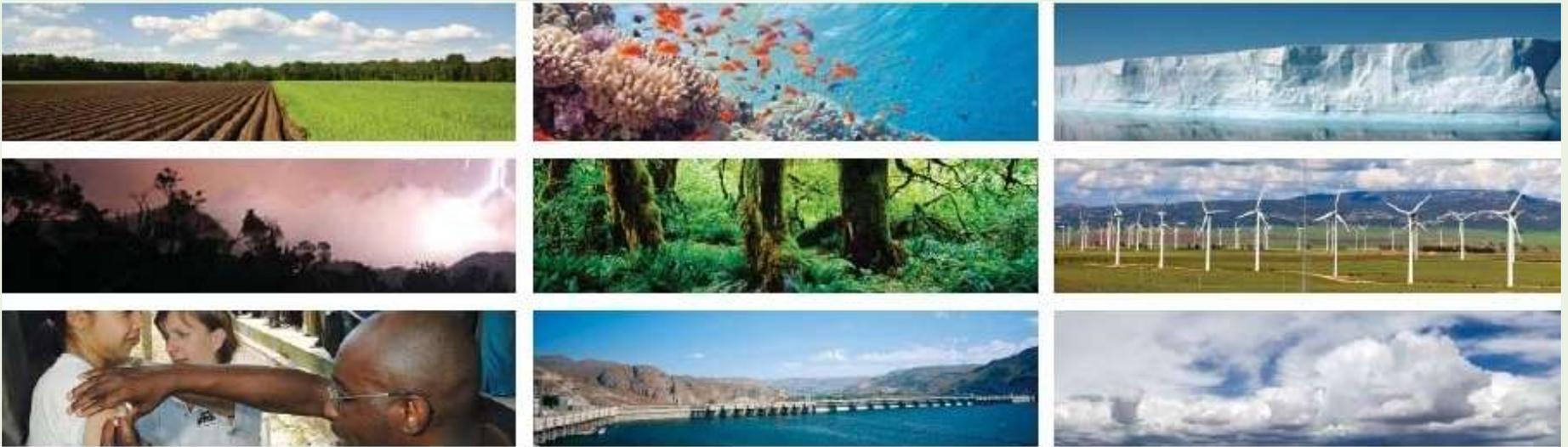# NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Satellite Enhanced Snowmelt Flood Predictions in the Red River of the North Basin (RRB)

PI Jennifer Jacobs
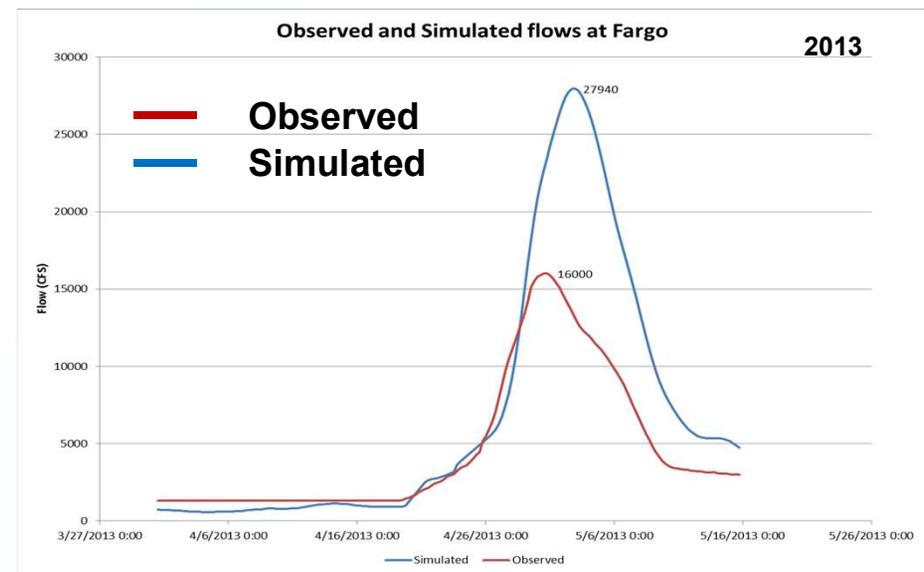
NASA Water Resources PI Meeting
June 26-28, 2018

Problem Statement & Opportunity

➢ **Problem: Challenges forecasting snowmelt floods.** 2013 forecasted peak flows were 74% higher than the observed flows at Fargo, ND.

➢ **Opportunity: Enhance snowmelt flood prediction** in the RRB using remote sensing estimates of snow and soil moisture states.
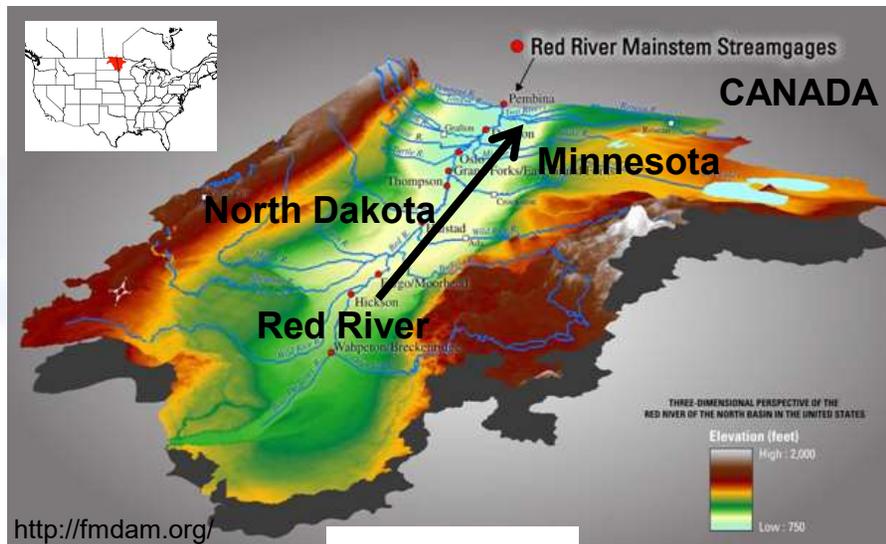

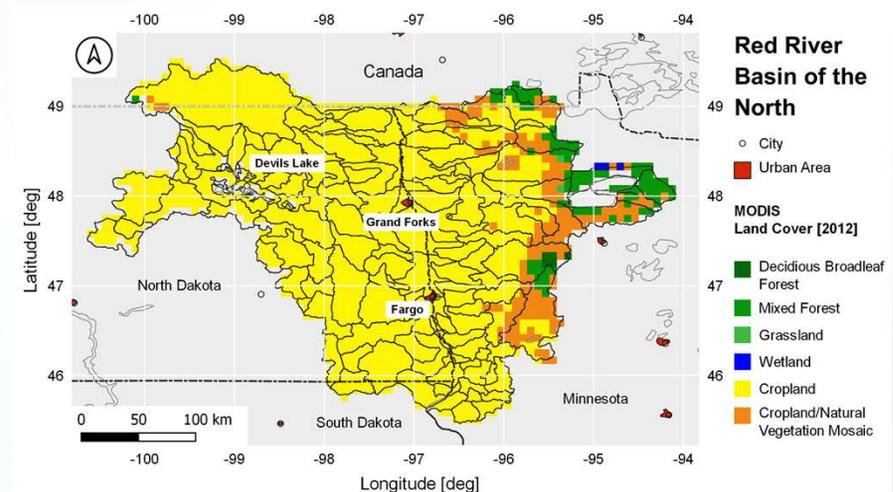Courtesy of M. DeWeese, NCRFC

2

Why does it matter?

- ➢ **RRB** is highly **prone to spring** snowmelt **flooding**
- ➢ **Flood damages of $3.5 billion** in 1997 flood alone

Terrain

Land Cover

- ➢ **Flat terrain** (1-2 feet/mile)
- ➢ **River flow is south-to-north** (ice jams)

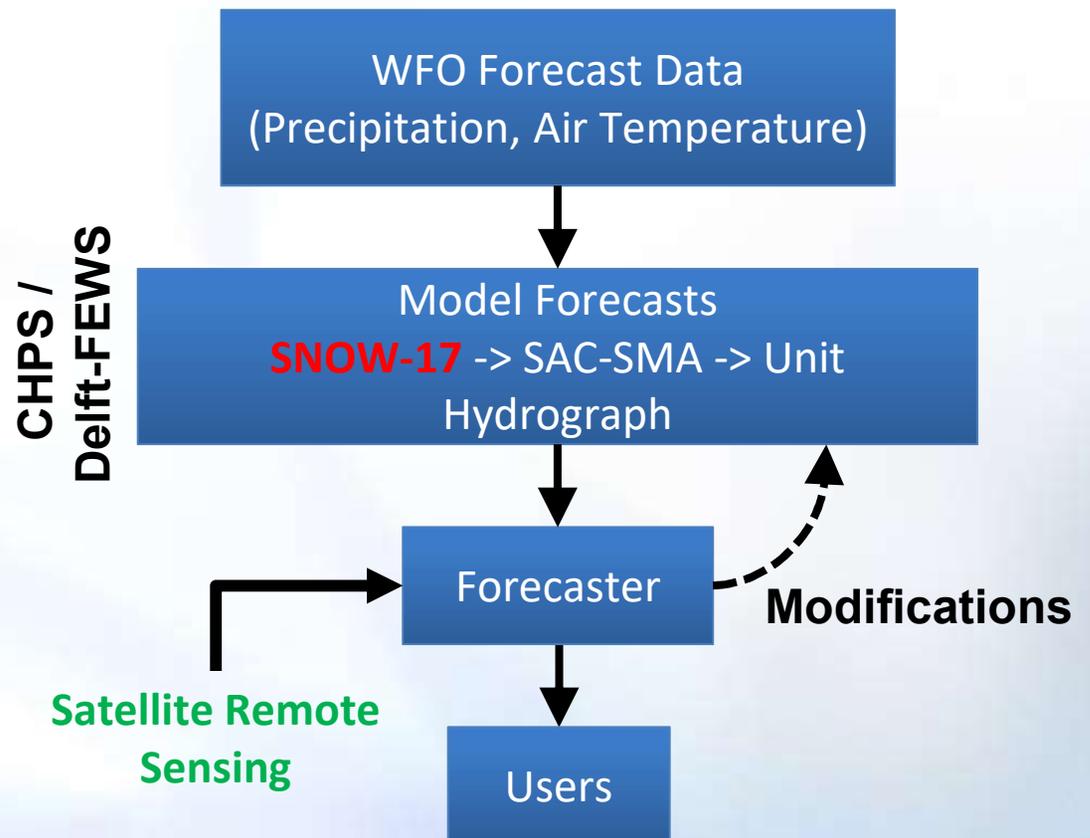- ➢ **Agriculture** (croplands) is the region's **largest industry**

3

How can satellite remote sensing data improve flood predictions?

Snowmelt Flood Forecast:

- Currently, flood and seasonal snowpack forecast relies on model simulations (e.g. **SNOW-17**) and sparse ground observations

- Daily **Satellite Remote Sensing** observations of snow give a new, and improved representation of the amount and condition of snow in the RRB

- Spaceborne snow observations will likely produce improved snowmelt flood forecasts

CHPS / Delft-FEWS

WFO Forecast Data
(Precipitation, Air Temperature)

↓

Model Forecasts
SNOW-17 -> SAC-SMA -> Unit Hydrograph

↓

Forecaster

Satellite Remote Sensing

Modifications

↓

Users

How can satellite remote sensing data improve flood predictions? (cont.)

➢ Snow Satellite Remote Sensing (e.g. SWE) gives a new and improved representation of the amount and condition of snow in the RRB
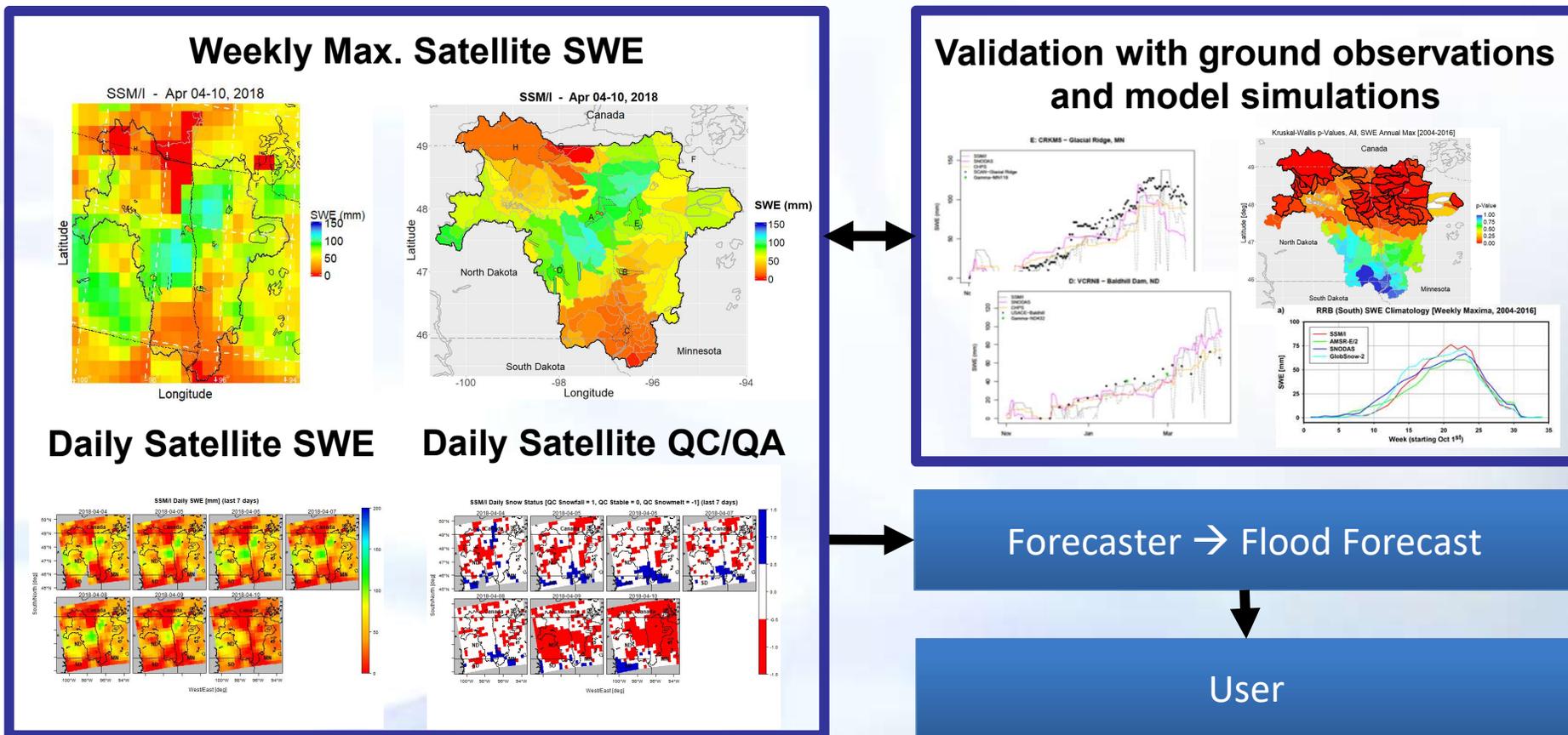
Weekly Max. Satellite SWE

Validation with ground observations and model simulations

Daily Satellite SWE   **Daily Satellite QC/QA**

Forecaster ➔ Flood Forecast

User

5

Impacts (achieved and anticipated)

Impacts achieved:

➤ Mature North Central River Forecast Center (NCRFC) and UNH ASP partnership developed over four winter seasons

➤ Weekly and daily quality controlled NRT-satellite SWE maps (SSM/I) to the NCRFC for use during operational forecasting

➤ Daily satellite snow status maps produced and delivered to the NCRFC

➤ Expanded data products accessible by the NCRFC forecasters i.e. satellite observations

Impacts anticipated:

➤ Application system completed and qualified in 2019 (ARL 8)

➤ Operational use of daily satellite SWE data at NCRFC

Publications

- **Vuyovich, C.M., J. Jacobs, T. Baldwin, S. Daly, & M. Reilly-Collette. Evaluation of satellite-based snow data for estimating SWE and SCA for water resource applications.** 2nd International Satellite Snow Products Intercomparison Workshop, 14 - 16 September 2015, Boulder, CO.

- **Jacobs, J.M., Vuyovich, S. Tuttle, E. Cho, X. Jia, M. Cosh, P. Restrepo, & S. Lim. 2015. Satellite Enhanced Snowmelt Flood Predictions in the Red River of the North Basin (RRB).** SMAP-Canada Workshop, 27-28 October, 2015, Winnipeg, Canada. Invited Speaker.

- **Tuttle, S. E., Jacobs, J., Vuyovich, C., Cho, E., Restrepo, P., Jia, X., Cosh, M., DeWeese, M., Connelly, B., & Buan, S. Remote Sensing Observations of Snow and Soil Moisture for Snowmelt Flood Predictions in the Red River of the North Basin.** Abstract H51T-01. AGU Fall Meeting, 14-18 December 2015, San Francisco, CA.

- **Tuttle, S., Cho, E., Vuyovich, C., Olheiser, C., & Jacobs, J. Comparison of Satellite Passive Microwave, Airborne Gamma Radiation Survey, and Ground Survey Snow Water Equivalent Estimates in the Northern Great Plains.** Oral presentation at 73rd Eastern Snow Conference, 14-16 June 2016, Columbus, OH.

- **Cho, E., Tuttle, S., & Jacobs, J. Comparison between AMSR2 and AMSR-E Snow Water Equivalent using SSM/I over the North Central U.S.** Poster presented at 73rd Eastern Snow Conference, 14-16 June 2016, Columbus, OH.

- **Vuyovich, C., Jacobs, J.M., Hiemstra, C.A., Deeb, E.J., & Eylander, J.B. (2016). Sensitivity Analysis of passive microwave brightness temperatures to distributed snowmelt.** Poster presented at 73rd Eastern Snow Conference, 14-16 June, Columbus, OH.

- **Tuttle, S.E., Cho, E., Restrepo, P.J., Jia, X., Vuyovich, C., Cosh, M., & Jacobs, J. (2017). Remote Sensing of Drivers of Spring Snowmelt Flooding in the North Central U.S. (Chapter 2),** *In* Remote Sensing of Hydrological Extremes, V. Lakshmi (ed.), Springer Remote Sensing/Photogrammetry, pp. 21-45, doi: 10.1007/978-3-319-43744-6_2.

- **Tuttle, S.E., Restrepo, P.R., DeWeese, M.M., Connelly, B., Buan, S., & Jacobs, J.M. Improving River Flow Predictions from the NOAA NCRFC Forecasting Model by Incorporating Satellite Observations.** Abstract H51H-1617. AGU Fall Meeting, 12-16 December 2016, San Francisco, CA.

- **Schroeder R., Jacobs J.M., Vuyovich C.M., Cho E., Jia X., Cosh M., Olheiser C., DeWeese M.M., Connelly B., Buan S., Restrepo P.J. and Tuttle S. Satellite microwave remote sensing of snow properties for optimal use in snowmelt flood forecasting in the Red River of the North basin.** Oral presentation at 74th Eastern Snow Conference, Ottawa, Ontario, Canada, 6-8 June, 2017

- **Vuyovich, C., J.M. Jacobs, C.A. Hiemstra, and E.J. Deeb. 2017. Effect of spatial variability of wet snow on modeled and observed microwave satellite observations.** Remote Sensing of Environment. 198. pp. 310-320.

Publications (cont.)

- **Cho, E., S.E Tuttle and J.M Jacobs, 2017. Evaluating Consistency of Snow Water Equivalent Retrievals from Passive Microwave Sensors over the North Central US: SSM/I vs. SSMIS and AMSR-E vs. AMSR2.** Remote Sensing, 9(5). p.465.

- **Schroeder R. and Jacobs J.** *Satellite Enhanced Snowmelt Flood Predictions in the Red River of the North Basin (RRB), Oral Presentation at NASA Water Resources PI Meeting, Pasadena CA, July 18-19, 2017*

- **Schroeder R., J.M. Jacobs, C. M. Vuyovich, M.H. Cosh, X. Jia, M. M. DeWeese, B. Connelly, S.E. Tuttle Evaluation and application of gridded snow water equivalent products for improving snowmelt flood predictions in the Red River basin of the North,** *Abstract* H13I-1504 AGU Fall Meeting, 11-15 December 2017, New Orleans, LA.

- **Schroeder R., J.M. Jacobs, C. M. Vuyovich, E. Cho, X. Jia, M.H. Cosh, C. Olheiser, M. M. DeWeese, B. Connelly, S. Buan, P.J. Restrepo, S.E. Tuttle Assessment of Passive Microwave Satellite and Modeled Snow Water Equivalent Estimates in the Red River Basin of the North: Improving Snowmelt Flood Predictions** *Paper* 11B.2*, AMS Annual Meeting, January 7-11, 2018*

- **Cho E, J.M. Jacobs, S.E. Tuttle, C. Olheiser Improvement of airborne gamma radiation snow water equivalent (SWE) estimations with spaceborne soil moisture observations** *Oral presentation* at 75th Eastern Snow Conference 5-8 June, 2018, Greenbelt, MD.

- **Schroeder R., S. Kraatz, J.M. Jacobs, C. M. Vuyovich, C. Olheiser, B. Connelly, M. M. DeWeese Detection of snowmelt signals for improving snowmelt flood forecasts in the Red River basin of the North** Poster presented at 75th Eastern Snow Conference, 5-8 June 2018, Greenbelt, MD.

Thank you!

J Jacobs, C Vuyovich, X Jia, M Cosh, R Schroeder, E Cho, M DeWeese, C Olheiser, B Connelly, P Restrepo