The impact of SMAP data assimilation on Tropical Cyclone landfall predictions

SMAP Science Team Meeting
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Can the assimilation of SMAP observations into a global numerical weather prediction (NWP) model improve the prediction of tropical cyclone (TC) evolution prior to and after landfall?
Can the assimilation of SMAP observations into a global numerical weather prediction (NWP) model improve the prediction of tropical cyclone (TC) evolution prior to and after landfall?

Motivation:
- For forecasting a TC approaching land, or after landfall, land surface initial conditions are significantly more important
  - Very wet land surface → help to sustain or re-intensify TC ("Brown Ocean Effect")
  - Dry land surface → faster TC dissipation
  - Soil moisture gradients → different TC over-land track
- SMAP data assimilation → better land surface initial conditions → better TC forecasts → societal benefit

**Figure 3:** Accumulated precipitation and 50mm accumulated precipitation from TC Idai for March 16-17, 2019. Figure again demonstrates the dramatic changes in precipitation [mm] and 50mm accumulated precipitation as a result of the land surface conditions. The figure shows the simulated precipitation produced by Idai during the 2 days when Idai was stationary near Madagascar, in the two configurations (CNTRL and DRY), compared to observations from the NASA Integrated Multi-satellitE Retrievals for GPM (IMERG, GMAO). The figure again demonstrates the dramatic changes in precipitation [mm] and 50mm accumulated precipitation.
Observing System Experiment to determine the potential of SMAP data assimilation to improve forecasts of tropical cyclone structure and precipitation surrounding landfall.

Control:
- Forecasts of TC from analysis constrained by standard suite of atmospheric observations

Experiment:
- Additional constraint through SMAP Tb observations

Evaluation:
- Combination of global skill metrics, regional tailored metrics and phenomenological approaches to evaluate impact on TC forecast skill
The Land-Atmosphere Data Assimilation System
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- Assimilates SMAP Tbs every 3 hours
- Catchment Land Surface Model
- Based on L4 SM system (assimilation window, bias correction approach, RTM)

Land surface states and fluxes constrain atmospheric states and fluxes
→ Changes made through SMAP DA feed back to the atmosphere

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More information on LADAS in SMAP ST presentation by R. Reichle on July 7th, 2021

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Case Study: Tropical Cyclone Idai (March 4 – March 16, 2019)
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First landfall on March 4, 2019
Second landfall on March 15, 2019
Final dissipation

TC genesis
Case Study: Tropical Cyclone Idai

Vorticity Mar 04 12z

Streamlines show TC circulation

Vorticity Mar 11 0z

Vorticity Mar 15 0z

Vertically integrated vorticity [kg m$^{-2}$ s$^{-1}$]

SM anomaly (SMAP-clim) Mar 04 12z

SM anomaly (SMAP-clim) Mar 11 0z

SM anomaly (SMAP-clim) Mar 15 0z

Surface soil moisture [m$^3$ m$^{-3}$]

GMAO

gmao.gsfc.nasa.gov
What can SMAP add?

- The SMAP DA run captures the wetter than normal conditions better than a model run that is not constrained by SMAP
  → By assimilating SMAP we could improve the forecast of Idai’s behavior
Ongoing work:

- Setting up and running OSE control experiment for Idai
- Setting up and running OSE DA experiment for Idai
  → Assess the impact SMAP DA has on our ability to predict Idai’s behavior

Future work:

- Repeat Idai experiment for a range of TC case studies
  → Determine how large scale forcing may modulate the impact of SMAP DA
  → *Determine the impact of SMAP DA on the overall model forecast skill*
Thank you!