The SMAP Level-4 ECO Project:
Linking the terrestrial water and carbon cycles

J. Kolassa\textsuperscript{1,2}, R.H. Reichle\textsuperscript{1}, Q. Liu\textsuperscript{1,3} and R. Koster\textsuperscript{1}

Science Utilization of SMAP Meeting
20 October, 2017

(1) Global Modeling and Assimilation Office, NASA Goddard Spaceflight Center
(2) Universities Space Research Association, GESTAR
(3) Science Systems and Applications
Outline

1. The Level-4 ECO Project
2. Catchment vs. Catchment-CN
3. SMAP Level-2 Passive Assimilation
4. Modeled vs. Observed FPAR
5. Next Steps
The L4-ECO project

Objective: Develop a **fully coupled hydrology-vegetation data assimilation** algorithm to generate improved estimates of hydrological fields and carbon fluxes
The L4-ECO project

**Objective:** Develop a fully coupled hydrology-vegetation data assimilation algorithm to generate improved estimates of hydrological fields and carbon fluxes

**L4 Soil Moisture:**
Assimilate SMAP observations into a land surface hydrology model to generate improved soil moisture estimates

**L4 Carbon:**
Use L4 SM estimates and MODIS fraction of absorbed photosynthetically active (FPAR) observations in carbon model to estimate carbon fluxes
The L4-ECO project

Objective: Develop a fully coupled hydrology-vegetation data assimilation algorithm to generate improved estimates of hydrological fields and carbon fluxes

L4 Soil Moisture:
Assimilate SMAP observations into a land surface hydrology model to generate improved soil moisture estimates

L4 Carbon:
Use L4 SM estimates and MODIS fraction of absorbed photosynthetically active (FPAR) observations in carbon model to estimate carbon fluxes

Land surface hydrology impacts biosphere (carbon fluxes), but not vice versa
The L4-ECO project

L4 ECO:

- Catchment-CN: Coupled land surface hydrology model (Catchment) and dynamic vegetation model (CLM4) to allow full feedback

Catchment-CN (Koster et al., 2014)

CLM4 dynamic vegetation model (Oleson et al., 2010; Thornton et al., 2007)

Catchment land surface model (Koster et al., 2000; Ducharne et al., 2000)
The L4-ECO project

L4 ECO:

- Catchment-CN: Coupled land surface hydrology model (Catchment) and dynamic vegetation model (CLM4) to allow full feedback

- Assimilate:
  - MODIS FPAR
  - SMAP brightness temperatures (Tbs)
The L4-ECO project

L4 ECO:

- **Catchment-CN**: Coupled land surface hydrology model (Catchment) and dynamic vegetation model (CLM4) to allow full feedback

- **Assimilate**: 
  - MODIS FPAR
  - SMAP brightness temperatures (Tbs)

Generate improved estimates of hydrological fields and carbon fluxes
Catchment vs. Catchment-CN

Evaluation against CVS data

**Surface**
- Correlation
- $\text{abs(bias)}$ [m$^3$/m$^2$]
- ubRMSE [m$^3$/m$^2$]

**Root zone**
- Correlation
- $\text{abs(bias)}$ [m$^3$/m$^2$]
- ubRMSE [m$^3$/m$^2$]

Legend:
- Red: Catchment-CN
- Blue: Catchment
Catchment vs. Catchment-CN

Evaluation against CVS data

• Surface: Catchment-CN improves correlations but slightly degrades ubRMSE compared to Catchment
• Root-zone: slight skill degradation with Catchment-CN
Assimilation of SMAP L2SMP

Evaluation against CVS data
Assimilation of SMAP L2SMP

Evaluation against CVS data

• Assimilation of SMAP L2P retrievals yields correlation and ubRMSE skill improvements in both cases
• Slightly smaller surface skill improvements for Catchment-CN, because of improved model skill
Catchment-CN FPAR vs. MODIS FPAR

Mean FPAR Apr 2015 - Mar 2017
Catchment-CN FPAR vs. MODIS FPAR

- Model and observations show strong discrepancies in absolute values and dynamics
- Differences may be too large to correct through assimilation alone
Catchment-CN FPAR vs. MODIS FPAR

- Model and observations show strong discrepancies in absolute values and dynamics
- Differences may be too large to correct through assimilation alone

→ calibrate Catchment-CN to obtain more realistic model simulations
Next steps…

(1) Calibrate Catchment - CN

- Use MODIS FPAR observations to estimate optimal vegetation parameters for Catchment-CN
- Obtain more realistic FPAR simulations
Next steps…

(1) Calibrate Catchment -CN
- Use MODIS FPAR observations to estimate optimal vegetation parameters for Catchment-CN
- Obtain more realistic FPAR simulations

(2) SM and FPAR assimilation
- Jointly assimilate SMAP Tbs and MODIS FPAR observations into calibrated Catchment-CN
- Test OCO-2 SIF assimilation
Next steps…

(1) Calibrate Catchment -CN
- Use MODIS FPAR observations to estimate optimal vegetation parameters for Catchment-CN
- Obtain more realistic FPAR simulations

(2) SM and FPAR assimilation
- Jointly assimilate SMAP Tbs and MODIS FPAR observations into calibrated Catchment-CN
- Test OCO-2 SIF assimilation

(3) Data generation
- Use fully coupled data assimilation system to generate improved estimates of hydrological fields and carbon fluxes
Thank you!
References

Reichle, R.H., Koster, R., Collatz, G.J. (NASA ROSES 2015 - SUSMAP), The SMAP Level 4 Eco-Hydrology Product: Linking the terrestrial water and carbon cycles through the joint assimilation of SMAP data and MODIS and OCO-2 vegetation observations


EXTRA SLIDES
Assimilating SMAP L2P SM into Catchment-CN

Evaluation against CVS data