SMAP Algorithms and Cal/Val Workshop

Algorithms Workshop Summary

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Workshop Goals (1)

- Critical community assessment of the SMAP Algorithm Theoretical Basis Documents (ATBDs)
  - Review current algorithms:
    - Will the algorithm outputs meet mission requirements?
    - Are the calibration requirements properly in place?
    - Are the required ancillary data available?
    - Has the validity of these algorithms been demonstrated through enough synthetic or field data?
  - Assess current vs. alternate algorithms
    - Are any existing good algorithms missing?
    - Have these alternate algorithms been properly validated?
  - Identify areas requiring further research and development
    - Are there obvious gaps, where good algorithms don't exist and therefore need to be developed?
    - Any missing ancillary data?

Workshop Goals (2)

- Prioritize Algorithm Research and Development Needs
  - Algorithm attributes
    - Accuracy
    - Efficiency
    - Versatility
    - Need for ancillary data
  - Validation
    - Numerical
    - Field experiments
  - Costs
    - What resources are available?
    - How to optimize resource use?
    - How much time are you willing to spend?

Background: SMAP Data Products

Data Product	Description	Spatial Resolution (km)
L1B_S0_LoRes	Low resolution normalized radar backscattering coefficient in time order	30
L1C_S0_HiRes	High resolution normalized radar backscattering coefficient on Earth grid	1-3
L1B_TB	Radiometer brightness temperature in time order	40
L1C_TB	Radiometer brightness temperature on Earth grid	40
L3_F/T_HiRes	Freeze/Thaw state on Earth grid	3
L3_SM_40km	Radiometer-derived soil moisture on Earth grid	40
L3_SM_A/P	Radar-Radiometer soil moisture on Earth grid	10
L4_SM	Surface and root-zone soil moisture on Earth grid	10
L4_C	Carbon net ecosystem exchange on Earth grid	10

Current algorithms for generating each of above products were briefly presented. Several other presentations were made on additional and/or complementary algorithms. following pages contain a summary of discussions and suggestions at the workshop.

L1 Product issues and plans (1)

- L1 brightness temperature :
  - Error budget needs to be tightened to allow a margin of better than 0 Kelvin
  - Comments from Chris Ruf on this topic:
    - The SMAP radiometer L1 TB error budget contains a number of terms whose values are coupled. The values can be simultaneously varied (one going up and one going down) by adjusting the calibration algorithm. The RSS value of all component errors can be minimized by the proper design of the calibration algorithm. For example:
      - » NEDT error vs. RFI error: NEDT error depends on the time-bandwidth product of the subsampled data that is averaged together. Available time and frequency sub-samples are selected for inclusion in the average depending on the value of RFI detection metrics relative to detection thresholds. More conservative threshold settings will flag more data sub-samples and remove them from the average (raising the NEDT error). However, more conservative threshold settings will also lower the RFI error. These two effects can be traded off against one another by adjusting the threshold settings.
      - » NEDT error vs. dG/G and dTrx error: NEDT error depends on the duty cycle of antenna observations (the time spent looking out the antenna vs. the total time for antenna plus calibration observations). The dG/G and dTrx error depends on the frequency of calibration observations (the ability of the calibration algorithm to track system drifts). These two effects can be traded off against one another by varying the timing of the cal looks vs. antenna looks.
    - Some action items to address these issues:
      - » Develop detailed documentation describing the components of the L1 TB error budget. How were they determined? What assumptions were made about the calibration approach? What are the uncertainties in the assumptions?
      - » Identify any significant coupling between components of the L1 TB error budget. There may be other coupling mechanisms in addition to the two noted above. Develop a model that predicts the values of the coupled error components as a function of some common parameter of the calibration algorithm.
      - » Optimize the setting(s) of parameters that affect coupled errors so as to minimize the RSS value of the errors.

L1 Product issues and plans (2)

- L1 backscatter:
  - Post-launch calibration: how good is absolute calibration with extended targets such as the rain forest given that we don't have an "exact" known value of the forest backscatter?
    - Any way to use man-made targets with known cross sections at 1km resolution?
    - consider aircraft underflights (talk to DESDynI folks)
    - Consider large corner reflector arrays for antenna pattern measurement
  - Implement internal loop-back path for HV cal
  - Need to specify HV calibration requirement, if it is used in any of the algorithms (it IS used for vegetated surfaces and possibly open water areas ==> need requirement)
  - Converge on surface model to use for incidence angle correction
  - Incidence angle removal needs DEM: what to do above 57 degree latitude?
  - Ultimately may not be feasible or (computationally) cost-effective to do pixel-by-pixel incidence angle correction; will need to flag areas with average incidence angles exceeding some threshold

L3 Product issues and plans (1)

- L3 40km soil moisture (radiometer) :
  - Algorithms are mature for bare and vegetated surfaces
  - Corrections/modification needed for vegetated surfaces, e.g., input vegetation water content (VWC)
  - need more field data for VWC; look at accuracy of tau product for SMOS
  - Need % of water bodies in each pixel; how accurate is it?
  - Ancillary data sources generally need to be further defined
  - Several 1-page presentations suggested approaches for incorporating vegetation effects

L3 Product issues and plans (2)

- L3 hi-res soil moisture (radar):
  - Should we call the hi-res radar product a mission product? It is being used in A/P algorithm, so why not make it available as a mission product?
  - Algorithm options being evaluated; surface and vegetation models currently being benchmarked
    - Group needs to come up with a schedule for step-by-step delivery of algorithms/ algorithm pieces
    - Several 1-page presentations suggested additional approaches for bare soil and vegetated surfaces; will be considered as part of the overall evaluation
  - One possibility is constructing a data "cube" but needs to be combined with a smart search (optimization) technique since the cube for each channel is hyperdimensional especially in presence of vegetation
  - Vegetation effects still to be incorporated in algorithms; tricky to do with one frequency
  - Need to develop error assessment
    - Still need to specify calibration requirements for all channels
  - Validation: have to identify appropriate field data sets

L3 Product issues and plans (3)

- L3 10km active-passive:
  - Currently this product has very few (one) available algorithm options; needs more in-depth investigation
  - This new algorithm uses either L3 radar and radiometer products as starting point, or (optionally) L3 radiometer product and L1C radar product; uses radar-derived distributions to aid radiometer
  - Details to be finalized; expanded to larger regions
  - Needs to address issue with bias with active and passive products
  - Need field data to validate; coincident radar and radiometer data are rare

L3 Product issues and plans (4)

- L3 freeze-thaw (radar):
  - Algorithm needs pre-determined backscatter threshold values
    - These values need to be derived before launch, and updated post-launch
    - Need to look into existing satellite data for coming up with thresholds
  - Validation vis-à-vis scaling and heterogeneity to be addressed (as with all other algorithms)
  - Straightforward approach for L3 accuracy requirement validation
  - Where will soil thaw depth be addressed? Does it need to be a mission product? Application? Or to be possibly funded under a pre-launch ROSES element? (there was a 1-page presentation on this)
  - Where do we get soil texture information, especially outside of US?
  - Do we need to update our dielectric mixing models? (SMOS is apparently doing it)
  - Difficult to distinguish F/T signal for vegetation, snow and soil elements

L3 Product issues and plans (5)

- General issues related to L3:
  - Is the open water product L1 or L3? What is the algorithm to produce it? What is its accuracy? Who is going to produce it?
  - Do we need to produce a radar Texture product? May be helpful for open water, veg clasiffication, etc. Who will do it?
  - Who is going to pull together the master ancillary data sets?

L4 Product issues and plans (1)

- L4 (root zone) soil moisture:
    - Validation sites are sparse/suboptimal
    - Land surface models differ: which to use? Multi-model ensemble?
    - Integration of forward radiative transfer and land surface models
    - Does the bottom boundary parameter of the Catchment model (depth to bedrock) need improvement?
    - Only A/P product is planned for use; consider using active and passive retrieval products separately
    - Estimation and implementation of temporal/spatial error correlation scales?

L4 Product issues and plans (2)

- L4 Carbon:
  - Who will do the pre-launch activities to initialize model parameters? How intensive is the work?
  - Validation and field campaign requirements to be specific pre- and post-launch
  - Does the assumption that L4 soil moisture (L4_SM) is more accurate/suitable than L3 products need to be revisited?
  - What is the expected L4_SM accuracy over northern land areas and higher (>1.5 kg/m^2) Veg. biomass conditions?
  - Should soil thaw depth be an L4 product, or an input to L4 products?

- Question:
  - Should soil thaw depth be an L4 product, or an input to L4 products?

Beyond Currently Planned Products

- Other open issues:
  - Need for precipitation products:
    - Consider as part of ancillary data set?
    - Do we look at all available sets? How to pick the best set?
  - Why not use SMAP to map Faraday rotation?
    - To map Faraday rotation, will need to collect and downlink both HV and VH (currently only HV is to be downlinked)
    - Project to come up with a plan to address this issue: someone needs to quantify the benefits of finding Faraday rotation using quad pol radar vs. just using the 3rd Stokes parameter from the radiometer
  - Should compact polarimetry be implemented?
    - System modification is very small
    - Could save data volume; loses cross-pol
    - It is a viable option, but are the benefits enough to keep it on the table as an option to implement? To be discussed at July SDT meeting
  - **Other topics not included in above?**
    - How to support proposed activities?
    - ??

Next Steps

- Next workshop: tentatively March 5th, 2010, following MicroRad, Washington DC area

- Interested in joining the algorithms working group?
  - Email mmoghadd@umich.edu
  - Call 734-647-0244

- Might make sense to form algorithms working subgroups
  - Level 3 radiometer
  - Level 3 radar
  - Level 3 combined radar/radiometer

  - How about level 4 products?
  - How about Faraday rotation mapping?
  - How about compact polarimetry?