



The NISAR Mission

Ancillary Data Product Memo: Vegetation Water Content


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1. Overview

Vegetation water content (VWC) ancillary serves two purposes in the soil moisture algorithms: (1) to correct for the effect by vegetation during retrieval by the physical model inversion approach (2) to flag heavily-vegetated regions where the retrievals are deemed not so reliable such as forest. Ideally VWC should be derived from NISAR observations, because the information is concurrent and collocated with HH data. However, the current status is that the demonstration of the global applicability has yet to be achieved. As an alternative, VWC has been estimated using optical NDVI data from Landsat or MODIS [Hunt *et al.*, 2011]. The daily climatology of 1-km resolution VWC was generated by the SMAP project. As an interim source of the 200-m resolution VWC, the SMAP database was interpolated to 200-m.

2. Properties

The climatology VWC data has the following properties.

Temporal files	91 temporal files dated every 4-day interval. The dates will be day 1,5, 9,..., 361, 365.
Format	Global 200m grid with unsigned byte format
Scaling	The full dynamic range of 0 to 25.5 kg/m ² will be quantized to 255 level. Scaling factor is 0.1
Fill value	255 corresponding to no valid VWC value (water, ice, gap)
Size	Each day's file is 12.681 GB (byte format). The whole year's worth is 1.15TB (91 files) Each day, only two temporal files need to be loaded to PGE, corresponding to the memory size of 25.3 GB.

3. Processing

Temporal bilinear interpolation

Temporal bilinear interpolation of the temporal files will provide VWC at each time instance. Two VWC files at adjacent dates will be loaded to memory. For example, for day June 1, 2024 (day of year 153), the adjacent dates will be day 151 and day 154. Day 366 will be a copy of Day 365's data.

$$\Delta_1 = (153-151)$$

$$\Delta_2 = (154-153)$$

$$VWC_{153} = [\Delta_2 VWC_{151} + \Delta_1 VWC_{154}] / (\Delta_2 + \Delta_1)$$

Spatial bilinear interpolation

To derive VWC at 200m (target pixel), the values at eight surrounding 1 km pixels (source pixel) were interpolated using the bilinear weights.

Special care is needed when the source pixels do not have VWC value (such as water pixels). An accurate but time-consuming approach is to exclude the null 1km source

pixels when performing the interpolation at every 200m target pixel. But this approach is too time-consuming because of the large number of the 200m target pixels.

More efficient way is to expand into the null regions at 1km source layer. The null 1km pixel searches the surrounding eight 1km pixels and is assigned with an average of valid 1km VWCs out of the 8 pixels. Since we are only interested in populating the null (water) pixel next to land 1km pixels, there will always be at least one land 1km pixels.

Now the bilinear interpolation of the target 200m pixel within the valid 1km source pixel has no null source 1km inputs (middle panel in Figure 1).

The last step is to mask out the null value regions (as shown in 1km layer) from the 200m target layer (right panel in Figure 1). Because of the expansion and interpolation, smoothing occurs right up to the coast.

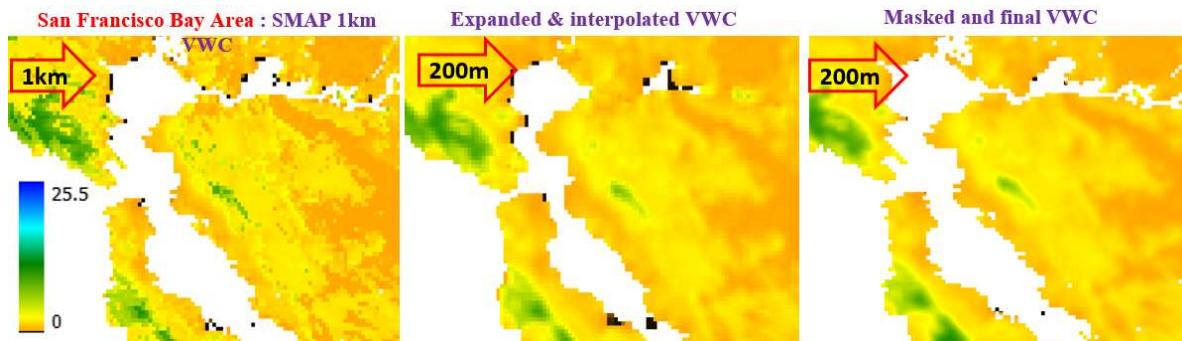


Figure 1. Spatial bilinear interpolation example. (left) source 1km VWC layer (middle) expansion into the null 1km region by one 1km pixel (right) target 200m layer after masking with the source 1km region of valid value. The unit is kg/m². The black and white colors refer to 0 and null, respectively. Black color shows the mud flat with 0 kg/m², which is adjacent to orange (0.1 kg/m²).

4. Results and Quality Control

An example of the global map is shown in Figure 2. The deserts were shown in black in order to highlight its spatial extent. Often the VWC 1km map has null values near water boundaries: wetland, cropland, urban, and more (Figure 3 with respect to google map; Figure 4 with respect to WorldCover land classification map).

The current understanding is that the permanent wetlands near water have null VWC value in the 1km layer (consequently 200m outputs, e.g., Louisiana and Everglades near Miami). However the null values are found over croplands and forest (Figure 3, India), which is not currently understood.

Processing from 250m may be able to better address this issue. Alternatively when VWC values are null, HV can be used to derive VWC. Some successful relationship were reported with radar vegetation index [Kim *et al.*, 2012] for wheat and pasture, or with HV [Liao and Kim, 2022] for corn and soybean.

Another group of artifacts are found in the Arctic showing the null values over the circumpolar region. Our understanding is that the cause is the projection transformation between MODIS sinusoidal and the EASE grid 2.

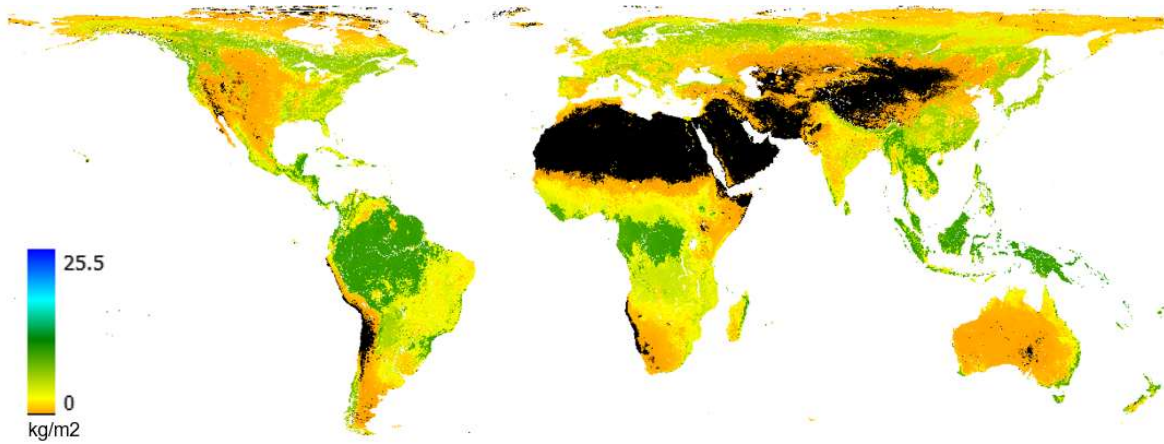


Figure 2. An example of the global 200m map.

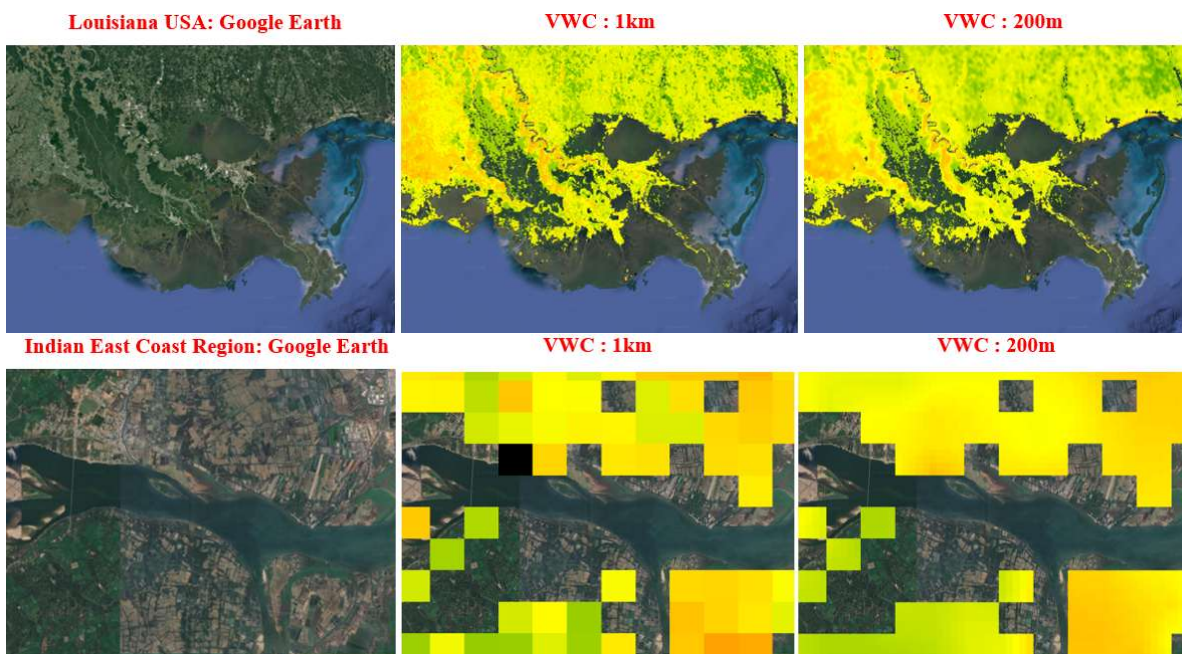


Figure 3. Comparison with Google map showing the absence of VWC values near water: over wetland (near New Orleans in this example) and over cropland in India.



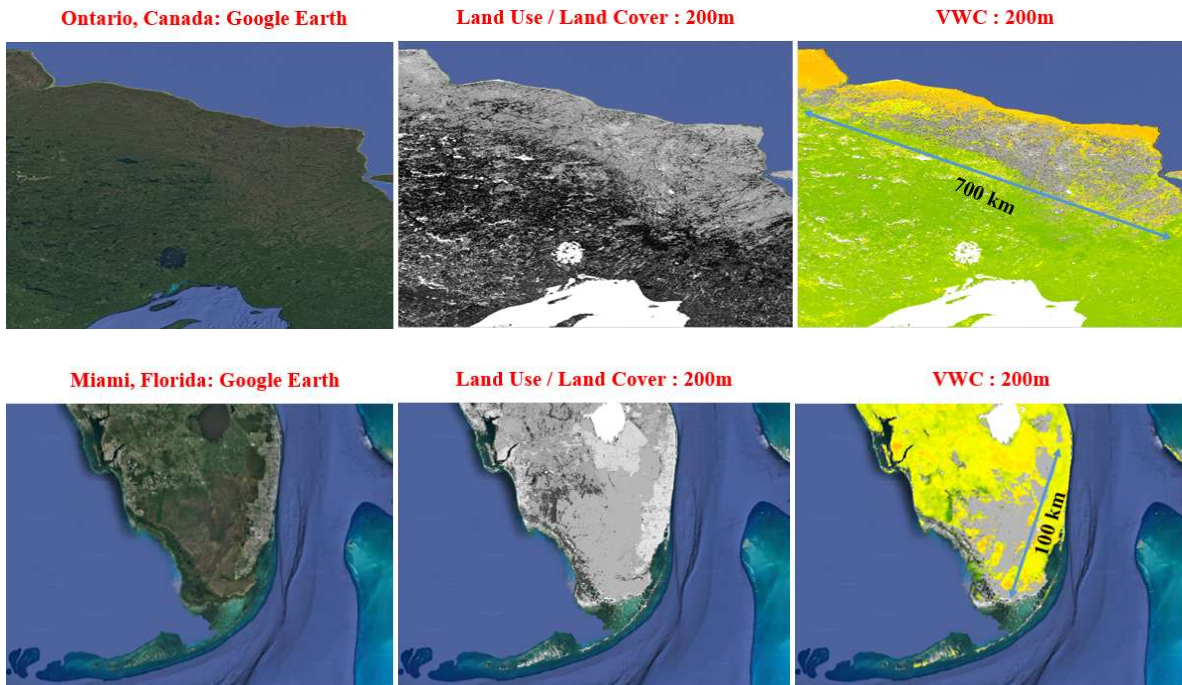


Figure 4. Comparison with WorldCover classification showing the absence of VWC values near water. White color in WorldCover corresponds to permanent waterbody. The rest of the grey scales indicate non-water classes.

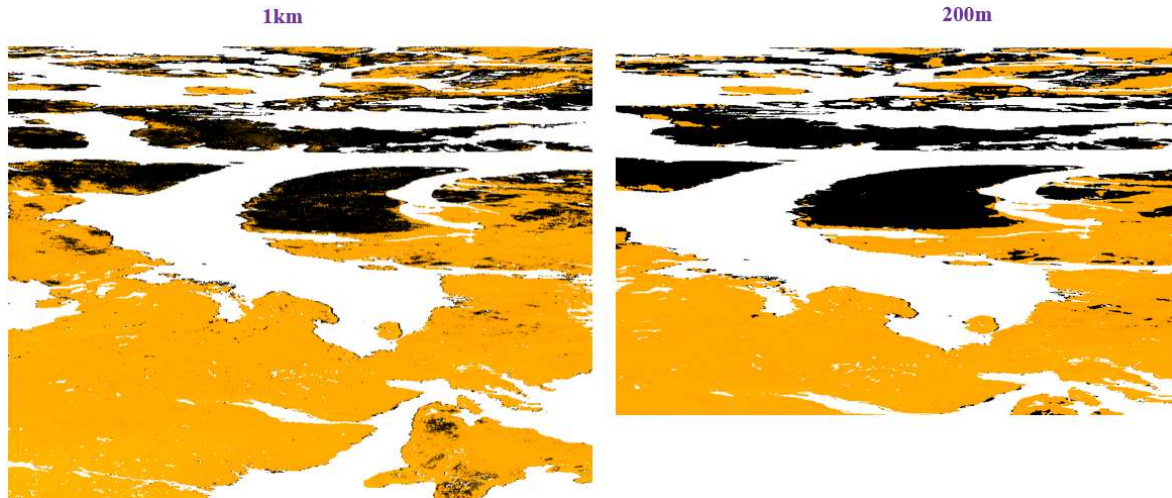


Figure 5. Artifacts in the Arctic showing the null values over the circumpolar region. Black and orange show VWCs of 0 and very low (~ 0.2) kg/m^2 .

5. Remaining work

This version of the VWC at 200m, derived from the 1km map, serves the purpose as the interim product that allows the R3.2 delivery PGE. This product shows two outstanding limitations

- 1) VWC values are null often near the water boundaries, far into the land (permanent waterbody, croplands, forest as identified by Google map and WorldCover)
- 2) Even if not null, the VWC values are void within 1km of water boundaries because 1km-resolution ocean mask was applied

The two limitations could be resolved by processing with 500-m MODIS NDVI, rather than 1-km VWC source. Whenever WorldCover class is non-water, derive VWC from 500m NDVI. If NDVI is null, interpolate if possible. If interpolation is not feasible near water boundaries, perform the extrapolation as implemented in this memo, or through nearest neighbor operation. The MODIS NDVI has 250m resolution, while 500-m NDVI has already been processed by the SMAP project. To save processing time, the team suggested the use of the 500-m NDVI. Alternatively HV can be used to derive VWC over the null NDVI pixels.

6. References

- Chan, S. et al. 2013. Ancillary data report for SMAP: vegetation water content. JPL document D-53061.
- Kim, Y., T. J. Jackson, R. Bindlish, H. Y. Lee, and S. Y. Hong (2012), Radar Vegetation Index for Estimating the Vegetation Water Content of Rice and Soybean, *IEEE Geoscience and Remote Sensing Letters*, 9(4), 564-568.
- Liao, T. H., and S. B. Kim (2022), Dual-frequency Retrieval of Soil Moisture from L- and S-band Radar Data for Corn and Soybean, *Remote Sens.*, submitted.