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Satellite Climate Studies Branch (SCSB)/CISESS

NOAA/NESDIS/STAR

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PUBLICATIONS

Atmospheric Motion Vector Bias and Uncertainty

Citation**: Lukens, Katherine E., Kayo Ide,** Kevin Garrett, **Hui Liu**, David Santek, Brett Hoover, and **Ross N. Hoffman**, 2021: Exploiting Aeolus Level-2B winds to better characterize atmospheric motion vector bias and uncertainty, *Atmos. Meas. Tech.,* **15**, 2719–2743, https://doi.org/10.5194/amt-15-2719-2022. Winds that are crucial to weather forecasting derived from two different techniques – tracking satellite features in images or Atmospheric Motion Vectors (AMVs) and direct measurement of molecular and aerosol motions by Doppler lidar (Aeolus winds) – are compared. We find that AMVs and Aeolus winds are highly correlated. Aeolus Mie-cloudy winds have great potential value as a comparison standard for AMVs. Larger differences are found in the Southern Hemisphere related to higher wind speed and larger vertical variations in wind.

Summary: CISESS Scientists Katherine Lukens (a former CISESS grad student!), Kayo Ides, Hui Liu and Ross Hoffman has a new article in the journal *Atmospheric Measurement Techniques* about their CISESS work with the NOAA/NESDIS Office of Projects, Planning, and Acquisition (OPPA) Technology Maturation Program (TMP) published on May 6. The need for highly accurate atmospheric wind observations is a high priority in the science community, particularly for numerical weather prediction (NWP). To address this need, this study leverages Aeolus wind lidar level-2B data provided by the European Space Agency (ESA) as a potential comparison standard to better characterize atmospheric motion vector (AMV) bias and uncertainty. AMV products from geostationary (GEO) and low Earth orbiting (LEO) satellites are compared with reprocessed Aeolus horizontal line-of-sight (HLOS) global winds from two observing modes, namely Rayleigh-clear (RAY; derived from the molecular scattering signal) and Mie-cloudy (MIE; derived from the particle scattering signal), observed in August–September 2019. As shown in other comparison studies, the level of agreement between AMV and Aeolus wind velocities (HLOSVs) varies with the AMV type, geographic region, and height of the co-located winds, as well as with the Aeolus observing mode. In terms of global statistics, quality controlled (QC'd) AMVs and QC'd Aeolus HLOSVs are highly correlated for both observing modes. Aeolus MIE winds are shown to have great potential value as a comparison standard to characterize AMVs, as MIE co-locations generally exhibit smaller biases and uncertainties compared to RAY co-locations. Aeolus RAY winds contribute a substantial fraction of the total standard deviation of co-location differences (SDCDs) in the presence of clouds where co-location/representativeness errors are also large. Stratified comparisons with Aeolus HLOSVs are consistent with known AMV bias and uncertainty in the tropics, NH extratropics, the Arctic, and at mid- to upper-levels in clear and cloudy scenes. AMVs in the SH/Antarctic generally exhibit larger-than-expected SDCDs, most probably due to larger AMV height assignment errors and co-location/representativeness errors in the presence of high wind speeds and strong vertical wind shear, particularly for RAY comparisons.

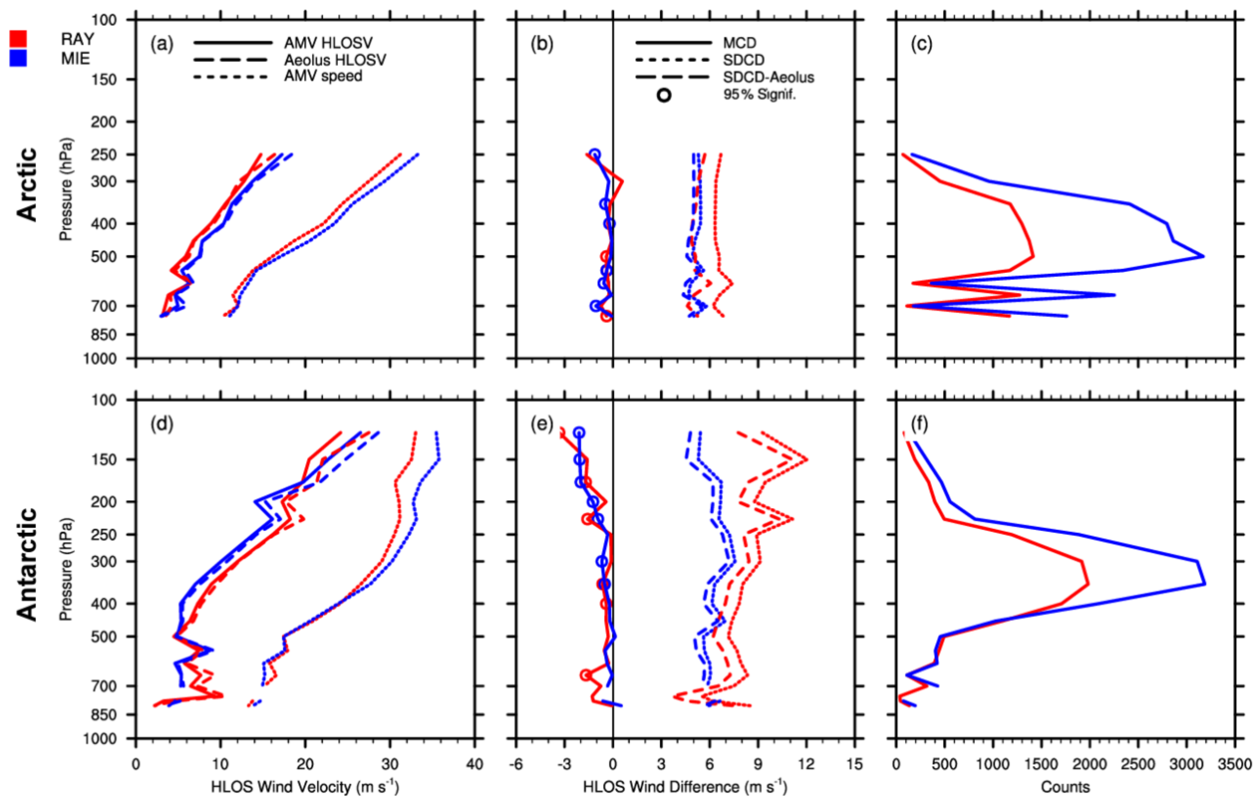

Figure: Vertical profiles of co-located LEO AMVs and RAY (red) and MIE (blue) winds. The top row shows the Arctic (north of 60° N), (a) mean AMV HLOSV (solid lines), Aeolus HLOSV (long dashed lines; m s^{-1}), and mean AMV wind speed (short dashed lines; m s^{-1}), (b) MCDs (solid), SDCDs (short dashed), and AMV HLOSV error, as represented by SDCD–Aeolus L2B uncertainty (long dashed; m s^{-1}), and (c) co-location counts. Panels (d–f) are as in panels (a–c) but for the Antarctic (south of 60° S). Colored open circles indicate levels where MCDs are statistically significant at the 95 % level (p value < 0.05), using the paired Student's t test. Vertical zero lines are displayed in the center panels in black. Levels with observation counts > 25 are plotted.

(POC: Katherine Lukens, CISESS, katherine.lukens@noaa.gov, Funding: OTM, STAR)

Soil Moisture and the Atmospheric Moisture Budget

Citation**:** Dennis, Eli J.; and E. Hugo Berbery, 2022: The effects of soil representation in WRF/CLM on the atmospheric moisture budget. *J. Hydrometeor.*, **23**, 681–696, http://dx.doi.org/10.1175/JHM-D-21-0101.1. This study uses seasonal coupled simulations to examine the uncertainties in the North American atmospheric water cycle that result from the use of different soil datasets. Mesoscale meteorology modeling shows shown that soil parameters can affect each variable in the atmospheric water budget.

Summary: CISESS Scientists Eli Dennis (another former CISESS grad student!), and Hugo Berbery have a new article published in the May 2022 issue of the *Journal of Hydrometeology* critiquing how models represent soil attributes. Soil hydrophysical properties are necessary components in weather and climate simulation, yet the parameter inaccuracies may introduce considerable uncertainty in the representation of surface water and energy fluxes. This study uses seasonal coupled simulations to examine the uncertainties in the North American atmospheric water cycle that result from the use of different soil datasets. Two soil datasets are considered: The State Soil Geographic dataset (STATSGO) from the U.S. Department of Agriculture and the Global Soil Dataset for Earth System Modeling (GSDE) from Beijing Normal University. Two simulations are conducted from 1 June to 31 August 2016–18 using the Weather Research and Forecasting (WRF) Model coupled with the Community Land Model (CLM) version 4 and applying each soil dataset. It is found that changes in soil texture lead to statistically significant differences in daily mean surface water and energy fluxes. The boundary layer thermodynamic structure responds to these changes in surface fluxes resulting in differences in mean Convective Available Potential Energy (CAPE) and Convective Inhabitation (CIN), leading to conditions that are less conducive for precipitation. The soil-texture-related surface fluxes instigate dynamic responses as well. Low-level wind fields are altered, resulting in differences in the associated vertically integrated moisture fluxes and in vertically integrated moisture flux convergence in the same regions. Through land–atmosphere interactions, it is shown that soil parameters can affect each component of the atmospheric water budget.

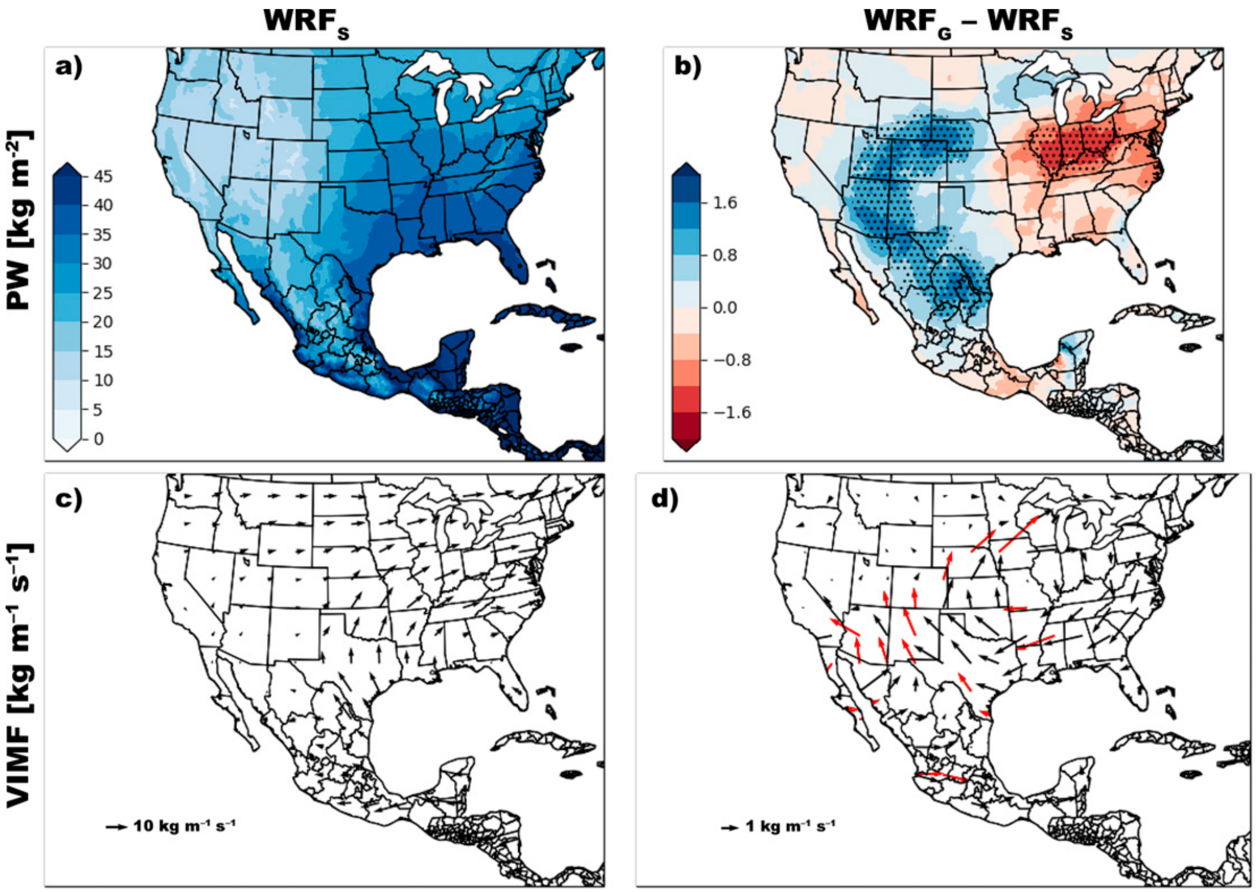

Figure: Three-year JJA-averaged quantities are shown for the WRF$_S$ simulation and (b), (d) the differences (WRF$_G$ - WRF$_S$) in those quantities, where S and G stand for the different soil datasets. (top) Precipitable water (kg m^{-2}) and (bottom) vertically integrated moisture flux vectors every 20 grid spaces (kg m s^{-1}). Stippled areas in (b) and red vectors in (d) show 90% confidence intervals ($p = 0.1$).

(POC: E. Hugo Berbery, CISESS, ernesto.berbery@noaa.gov, Funding: Task I)

Monitoring Forest Structure using JPSS VIIRS & GEDI-Lidar

Citation: Rishmawi, Khaldoun; Chengquan Huang; Karen Schleeweis and Xiwu Zhan, 2022: Integration of VIIRS observations with GEDI-lidar measurements to monitor forest structure dynamics from 2013 to 2020 across the Conterminous United States. *Remote Sens*., **14**, 2320. https://doi.org/10.3390/rs14102320. Techniques were developed to used high resolution Visible Infrared Imaging Radiometer Suite (VIIRS) from NOAA JPSS satellites along with NASA Global Ecosystem Dynamics Investigation (GEDI) waveform LiDAR to produce spatially consistent annual maps of key forest parameters, like canopy height. The methods in this study are expected to enable multi-decadal analysis of forest structure and its dynamics using consistent satellite observations from moderate resolution sensors such as VIIRS.

Summary: CISESS Scientists Khaldoun Rishmawi and Chengquan Huang, both from the UMD Department of Geographical Sciences, published a new article in the May 2, 2022 issue of the journal *Remote Sensing* discussing a new way to monitor forest structure by satellite. Consistent and spatially explicit periodic monitoring of forest structure is essential for estimating forest-related carbon emissions, analyzing forest degradation, and supporting sustainable forest management policies. To date, few products are available that allow for continental to global operational monitoring of changes in canopy structure. In this study, we explored the synergy between the NASA's spaceborne Global Ecosystem Dynamics Investigation (GEDI) waveform LiDAR and the Visible Infrared Imaging Radiometer Suite (VIIRS) data to produce spatially explicit and consistent annual maps of canopy height (CH), percent canopy cover (PCC), plant area index (PAI), and foliage height diversity (FHD) across the conterminous United States (CONUS) at a 1-km resolution for 2013–2020. The accuracies of the annual maps were assessed using forest structure attribute derived from airborne laser scanning (ALS) data acquired between 2013 and 2020 for the 48 National Ecological Observatory Network (NEON) field sites distributed across the CONUS. The root mean square error (RMSE) values of the annual canopy height maps as compared with the ALS reference data varied from a minimum of 3.31-m for 2020 to a maximum of 4.19-m for 2017. Similarly, the RMSE values for PCC ranged between 8% (2020) and 11% (all other years). Qualitative evaluations of the annual maps using time series of very high-resolution images further suggested that the VIIRS-derived products could capture both large and "more" subtle changes in forest structure associated with partial harvesting, wind damage, wildfires, and other environmental stresses. The methods developed in this study are expected to enable multi-decadal analysis of forest structure and its dynamics using consistent satellite observations from moderate resolution sensors such as VIIRS onboard JPSS satellites.

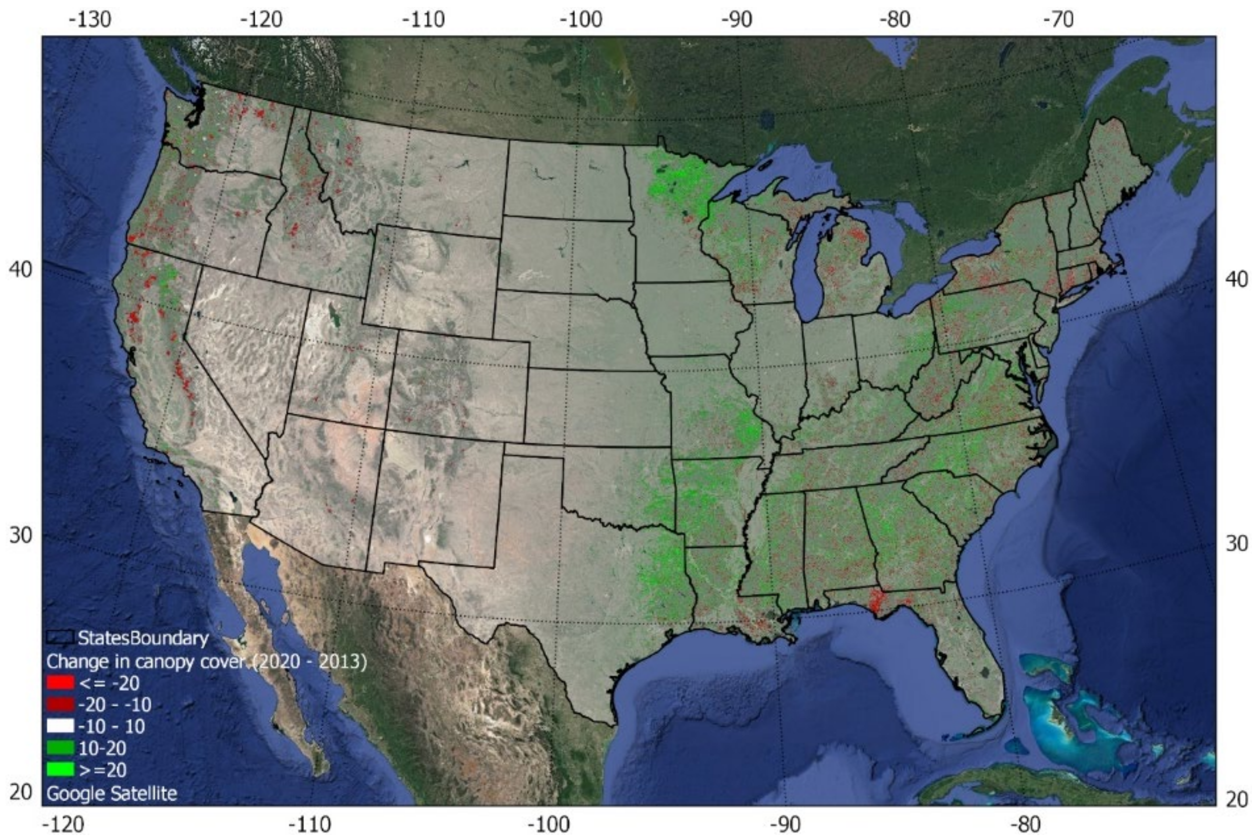

Figure: A map created using this method shows changes in percentage tree cover from 2013 to 2020 for the conterminous US. Over the period of 8 years, some 56,000 km^2 of western forests (west of -100° parallel) lost more than 10% of their tree cover while only 22,000 km^2 of forests increased their cover density by 10% or more.

(POC: Khaldoun Rishmawi, rishmawi@umd.edu , CISESS, Funding: JSTAR)