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Application of Deep Learning to Detection of Wildfire Smoke in HMS over North America

Kent Toshima

As wildfires are expected to increase in intensity and frequency in North America, wildfire smoke will be a larger environmental and public health concern in the coming decades. To tackle the problem, NOAA's Hazard Mapping System (HMS) provides the outline and density of wildfire smoke, which is used in air quality and public health studies. However, the data are produced by human analysts at NOAA who outline and classify wildfire smoke in near-real-time using satellite imagery. Our objective is to help automate the data production process by utilizing a state-of-the-art machine learning model. Here we present a version of a convolutional neural network (CNN) that produces smoke outline and density using satellite imagery from 2017-2019. Our model takes GOES-16 visible imagery over North America as input and classifies each pixel of the input into three different density levels of wildfire smoke. Our current model shows promising prediction accuracy for heavy smoke (43% of pixels correctly classified on test data) and is able to capture the shape of the smoke. In future work, we will incorporate more information into the model, such as distance to nearest fire, time of day and year, and meteorological variables, which we expect will help to improve the accuracy and precision of our model.

Agreement between the HMS Product and Ground-Level Smoke in the Pacific Northwest

Miah Caine

Recent studies have relied on smoke location and density data from NOAA's Hazard Mapping System (HMS) to show that exposure to PM from wildfire smoke is detrimental to public health in North America. Though this satellite-based product is used as a proxy for ground-level smoke, it has not yet been validated with ground-level data. Here we analyze the spatial and temporal agreement between the smoke and visibility datasets on hourly and daily timescales during the fire season in the Pacific Northwest (July - September) for 14 years (2005 - 2019). We assess the

HMS smoke product along with automated visibility and smoke data collected at the Seattle-Tacoma, Helena, Redding, and San Francisco airports. When using hourly observations, HMS captures only 31.3% of airport smoke hours observed during the fire season from 2005 - 2019. We identify two periods during the day across the four airports with unusually low HMS smoke observations – at midday and at night. In comparison to the 8,310 HMS smoke observations across all hours of the day, only 159 took place between 11:00 pm and 7:00 am EST and 1,310 between 12:00 pm and 4:00 pm. These reductions in observation appear to be due to HMS observational biases. We then aggregate the HMS and airport smoke and visibility time series from an hourly to daily time scale. When moving to the coarser, daily time scale, the percentage of airport smoke observations that the HMS product captured increases to 82.6%. Our research implies that the HMS product more accurately captures ground-level smoke at coarser temporal resolutions and is best suited for daily, monthly, or yearly scales or at carefully selected hours of the day.

2017 Update - Global Gridded Inventory of Methane Emissions from Oil, Gas, and Coal Exploitation

Shayna Grossman

We present a new version of the global inventory of methane emissions from oil, gas, and coal exploitation (Scarpelli et al., 2019). Individual countries report national emissions of methane, a potent greenhouse gas, in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). The global inventory spatially allocates the UNFCCC methane emissions to fossil fuel infrastructure. In the new version of the inventory we update the UNFCCC emissions to 2017 using the most recent reports by individual countries, and we incorporate new well information from Enverus to accurately represent the spatial distribution of oil and gas production emissions. For those countries without UNFCCC emissions we use updated activity data from the U.S Energy Information Administration and IPCC Tier 1 methods to estimate emissions.

Our inventory spatially allocates reported emissions for multiple subsectors of oil and gas exploitation (including leakage, venting, and flaring) at 0.1° x 0.1° resolution. Multiple databases are used to spatially allocate national emissions to infrastructure, including the updated wells from Enverus, oil and gas facilities and pipelines from GOGI, and coal mines from the most recent version of EDGAR. The inventory can serve as a prior estimate of emissions in inverse analyses of methane observations, including investigation of individual subsector contributions, and the inversion results can serve policy needs by evaluating the national emissions totals reported to the UNFCCC (Scarpelli et al., 2019).

Updating the Global Ethanol Budget Based on NASA Aircraft Observations

Ivan Specht

Deployed between 2016 and 2018, NASA's Atmospheric Tomography Mission (ATom) aircraft campaign provided some of the most detailed observations of trace atmospheric gases over the remote ocean. Among these gases was ethanol, whose reactivity with various species including atmospheric OH makes it worthy of study. In this presentation, I provide a method of updating the global ethanol budget by computing the chemical flux of ethanol over each ocean basin in each season, then inferring the oceanic contribution to ethanol production. Finally, I output some of the first-ever estimates of oceanic ethanol concentration in basins with sufficient data for such a computation.

Diagnosing Systematic Bias in TROPOMI Methane Retrievals

Margaux Winter

Daily, global satellite observations of methane column concentrations from the TROPOspheric Monitoring Instrument (TROPOMI) at 5.5 x 7 km^2 pixel resolution can improve our understanding of surface emissions through inversions of chemical transport models (CTM). Systematic biases in the observations or the CTM propagate to the resulting emissions estimate. We validate TROPOMI methane observations and the GEOS-Chem CTM over the North American domain from May 2018 through April 2019 using surface and aircraft data, paying particular attention to systematic biases with respect to latitude or albedo. We compare methane observations from the Atmospheric Tomography Mission (ATom) to a global 4° x 5° GEOS-Chem simulation to quantify latitudinal bias in the model. We use boundary and initial conditions from this simulation to model methane concentrations over North America at 0.5° x 0.625° resolution. We compare the output to data from ATom, the Total Carbon Column Observing Network (TCCON), NOAA Global Monitoring Laboratory (GML), Atmospheric Carbon and Transport (ACT) - America, and NOAA Observation Package (ObsPack). The model reproduces the observations with R=0.40 and an average bias of 21.85 ppb, which we remove from the simulated values. We find no systematic latitudinal bias. We also compare TROPOMI methane observations to the bias-corrected model, finding an average bias of 5.1 ppb, and R=0.41. We find large biases at low albedo values, which we attribute to the TROPOMI data. These biases are eliminated by considering only albedo values larger than 0.05. We also find a dependence of bias on latitude. We propose a correction for the TROPOMI data on the basis of these results, allowing for its use in inverse analyses.