BERKELEY LAB

Bringing Science Solutions to the World

U.S. DEPARTMENT OF ENERGY

UNIVERSITY OF CALIFORNIA

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COVID-19 Research at Berkeley Lab

Community Advisory Group (CAG) Meeting

Horst D. Simon

Deputy laboratory Director, Research

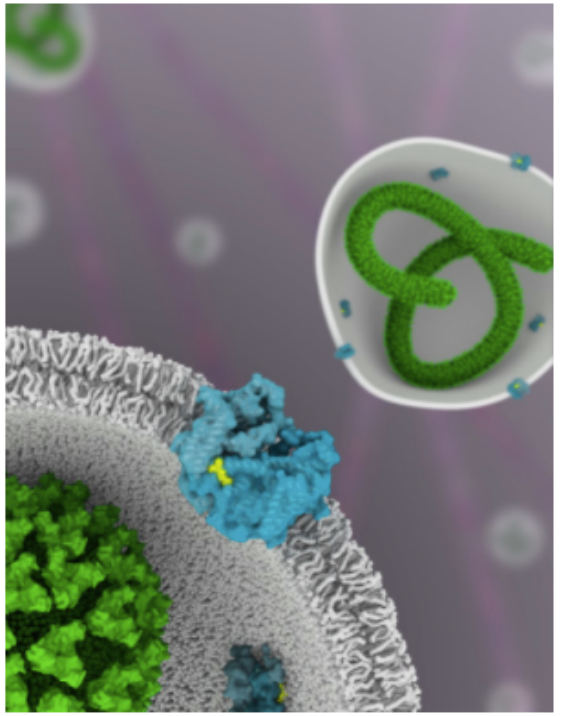
June 8, 2020

History of LBNL Support during National Emergencies

Ebola

Deepwater Horizon

Aliso Canyon



Artist's rendition of the TPC1 structure (blue) bound to the drug molecule, *trans*-Ned-19 (yellow). Ebola viruses that co-opt TPC1 during infection are depicted in green. Courtesy of Janet Iwasa (onemicron.com).

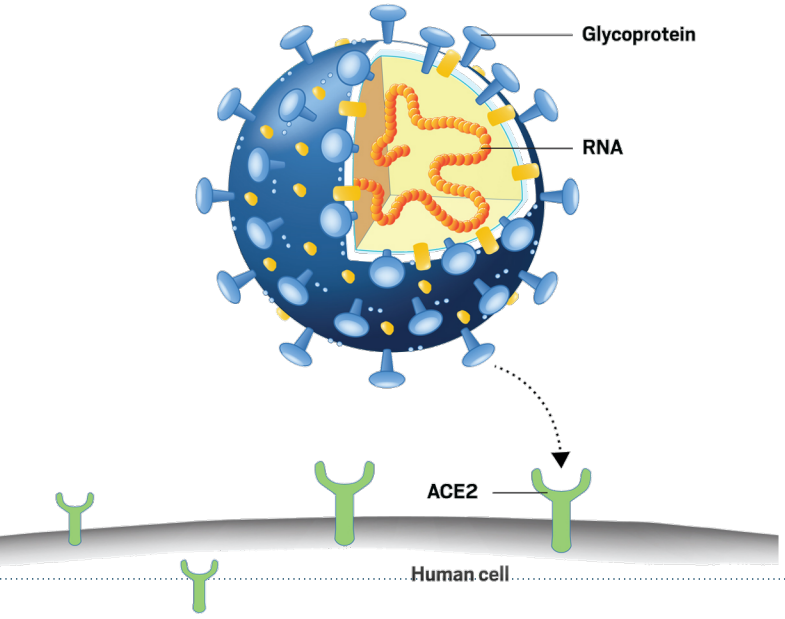
Quick Research Response to COVID-19 Pandemic

- DOE created National Virtual Biotechnology Lab (NVBL) to coordinate a response from all 17 National Labs
- National Covid-19 HPC Consortium formed (40 Consortium members, including LBNL)

Argonne NATIONAL LABORATORY
BERKELEY LAB
Lawrence Livermore National Laboratory
Los Alamos NATIONAL LABORATORY
OAK RIDGE National Laboratory
Sandia National Laboratories
TACC TEXAS ADVANCED COMPUTING CENTER
Ohio Supercomputer Center
NCAR
NASA
BLUE WATERS SUSTAINED PETASCALE COMPUTING
Open Science Grid
SDSC SAN DIEGO SUPERCOMPUTER CENTER
Google Cloud
IBM
aws
Microsoft Azure

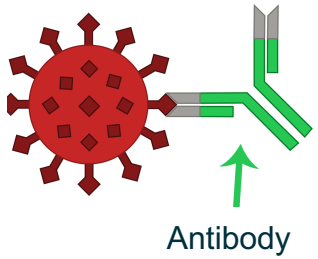
Attacking the Virus and Disease

Angiotensin-converting enzyme 2 (ACE2) is an enzyme attached to the outer surface of cells in the lungs, arteries, heart, kidney, and intestines. The virus' spike proteins bind to ACE2 and then enter the human cell.



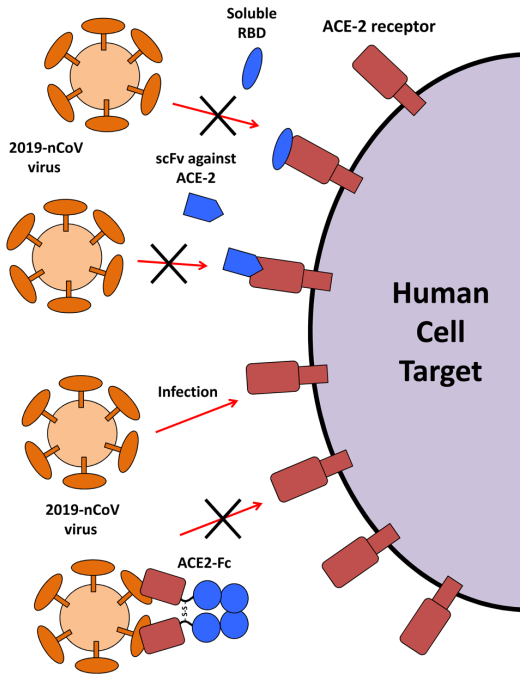
Vaccines trigger the body to make antibodies.

These spikes can be neutralized or blocked by antibodies.

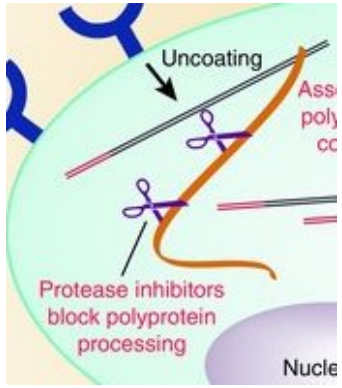


Antibodies are proteins produced by the immune system to fight infection.

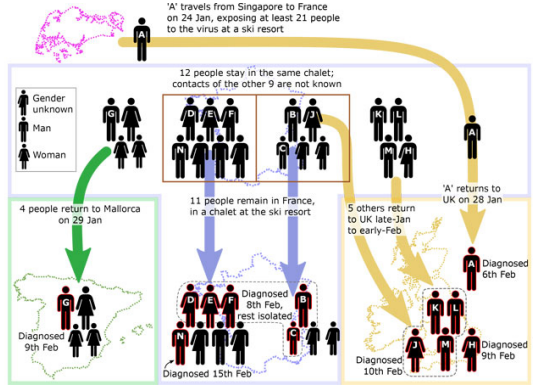
Much research focuses on finding safe molecules (drugs, blue shapes) that can block viral attachment.



Protease inhibitor drugs keep the virus from being able to manufacture its protective shell and spike proteins.



Other studies focus on modeling how the virus spreads (epidemiology) and how the environment affects it.



Current Berkeley Lab COVID-19 Efforts

- Received about $10M funding from DOE through CARES ACT
  - Three projects funded
  - Funding for user facilities (JGI, ALS, NERSC)
- Ongoing work at ALS, ABPDU, and Molecular Foundry
- Berkeley Lab COVID-19 **LDRD Funding** FY20 (6 projects)
- ECP (Exascale Computing Project) authorized rescope
- Berkeley Lab Automated Diagnostics Extension (BLADE) **UC Funding**

Aerosol and Indoor Air Quality Science to Strengthen Understanding of Airborne Disease Transmission

- This project aims to improve our understanding of mechanisms that impact the risk of airborne disease transmission in indoor spaces, focusing on transport and fate of respiratory aerosols
- Numerical models are used to estimate risks in varied scenarios defined by space and occupancy type and mitigations employed

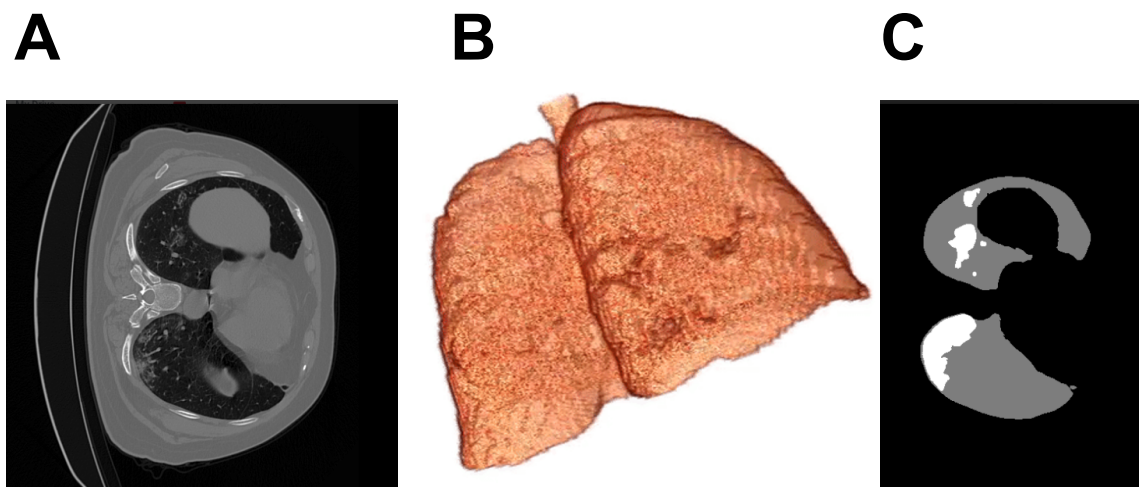
- Experiments in Berkeley Lab's FLEXLAB testbed elucidate impacts of mechanically-induced airflows, room configurations, barriers including masks, filtration, and other controls
  - Simulated ejections of respiratory fluids from talking and coughing are tracked to quantity near-field exposures

ACTS: Accelerating COVID-19 Testing through Screening

LDRD – P.I. Ushizima

Scientific Achievement

Automated screening of thoracic scans (3-D computed tomography) of patients with COVID-19 — detection of lung lesions predicted using graph-based segmentation and deep learning.



Significance and Impact

Lung lesions are key pathological findings for characterizing and assessing of COVID-19, associated with acute respiratory distress syndrome. This new mathematical model helps us automatically extract lungs (B) from thoracic CT scans (A), and delimitates regions of lesion (C) for future exploration of structures, such as consolidations and other pathological signatures.

(A): Slice of 3-D computed tomography;
(B): Graph-based lung segmentation (unsupervised);
(C): Mixed-scale densenet lesion prediction (supervised).

KG-COVID-19 Knowledge Graph for COVID-19 Response

Goal

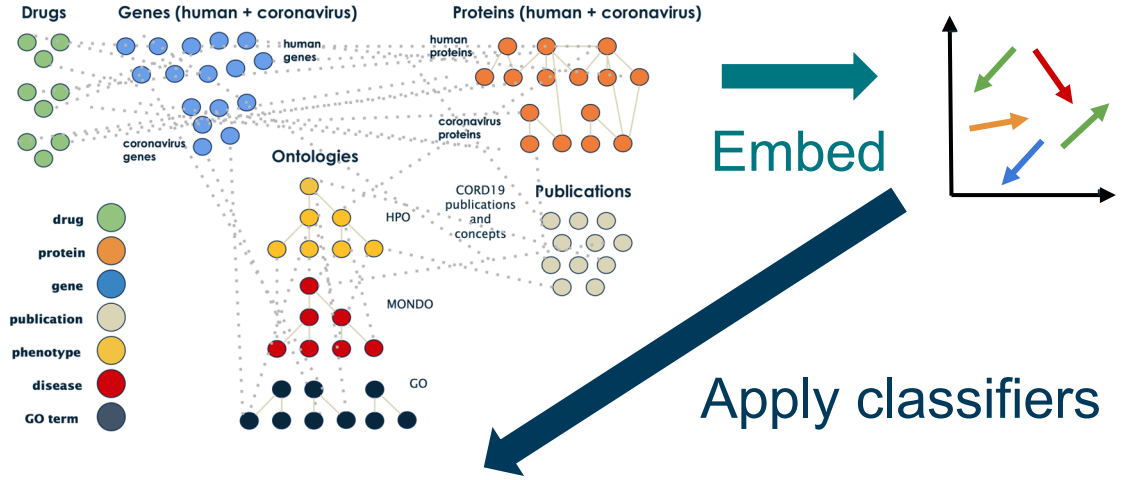
- Use Machine Learning (ML) to make useful COVID related predictions
  - e.g. drug repositioning

Challenge

- Data is siloed
- Traditional ML methods don't take into account interconnectedness

Approach

- Create a COVID-19 *Knowledge Graph (KG)*
- Develop graph *embeddings*
- Produce actionable knowledge



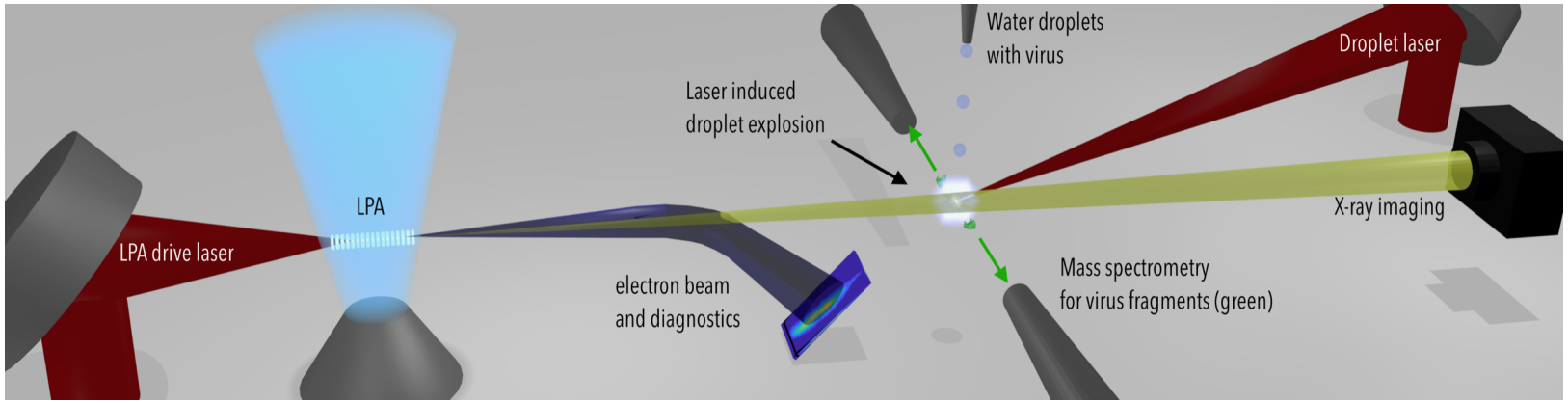
Actionable knowledge:

- COVID-19 drug candidates
- susceptibility genes

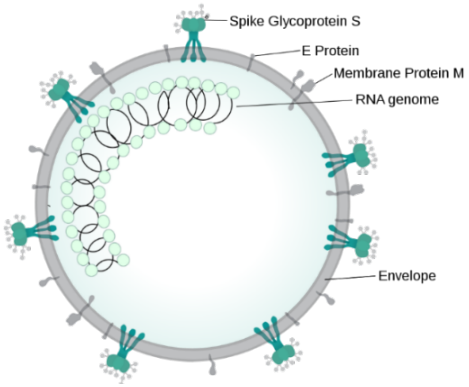
Project URL / GitHub Repository:
https://github.com/Knowledge-Graph-Hub/kg-covid-19

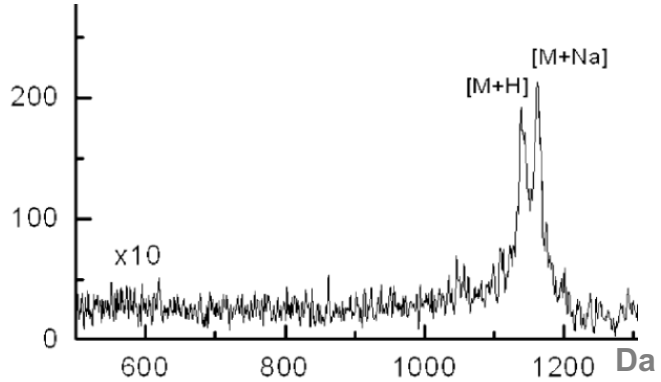
Berkeley Lab Team
Chris Mungall, Marcin Joachimiak, Deepak Unni, Justin Reese

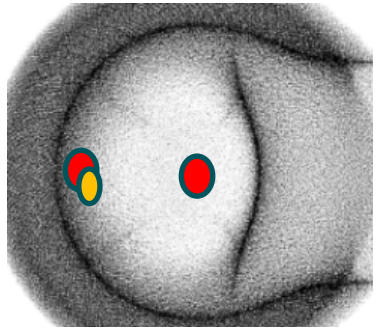
Microenvironments of SARS-CoV-2 in droplets – mass spectrometry and imaging with high power lasers



Schematic of SARS-CoV-2, example of bio-mass spectra and laser-plasma based imaging







Berkeley Lab Team
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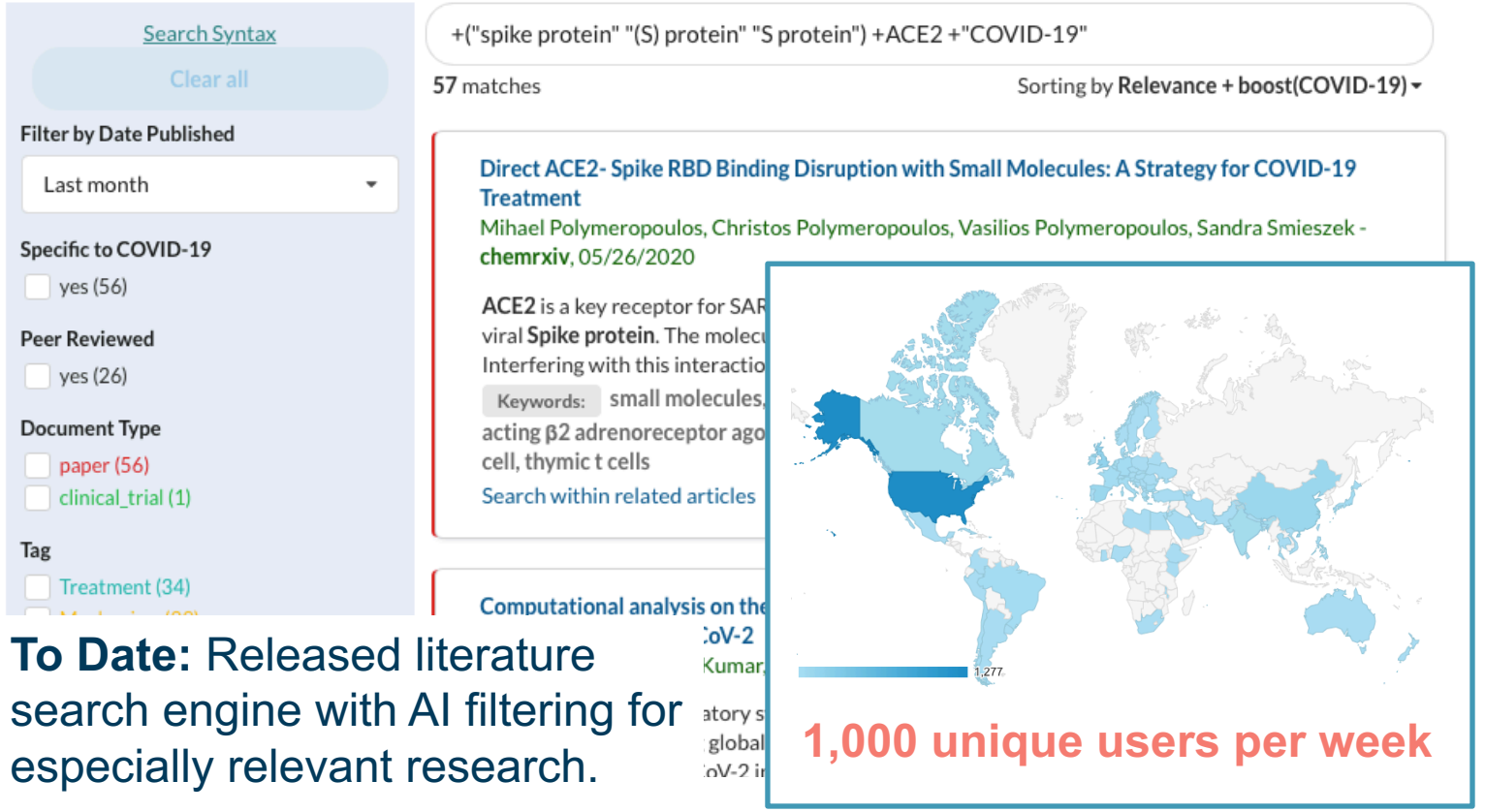
COVIDScholar: Accelerating Research with NLP Knowledge Discovery

Natural Language Processing (NLP) for textual analysis of research papers can aid in suggesting promising research directions.

- Automated pipeline for collection and **analysis** of research papers
- NLP tools for knowledge discovery



To Date: Released literature search engine with AI filtering for especially relevant research.

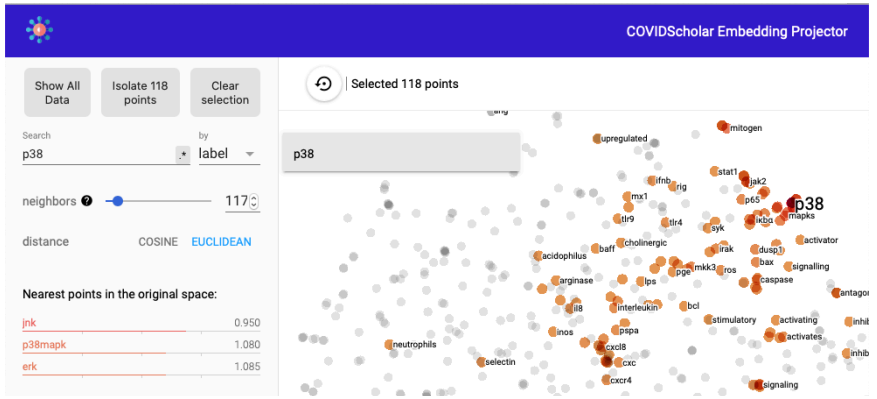
CovidScholar.org

COVIDScholar: Accelerating Research with NLP Knowledge Discovery

Ongoing Work:
Building tools that leverage unsupervised NLP to identify potential targets for therapies and other factors that contribute to disease dynamics.

- Intuitive 3D navigation interface to explore machine-learned relationships between proteins, genes, symptoms, and compounds
- Execute literature searches based on embedding subspaces
- Linking embeddings with KG-COVID knowledge graph project at LBNL

CoviDScholar.org



Data Collection:
80,000 papers, clinical trials, patents, …

- 28,000 papers on COVID-19
- 50,000 on related subjects
  - SARS, MERS, pandemic responses, immunology, etc
- Adding ~1500 new papers per week

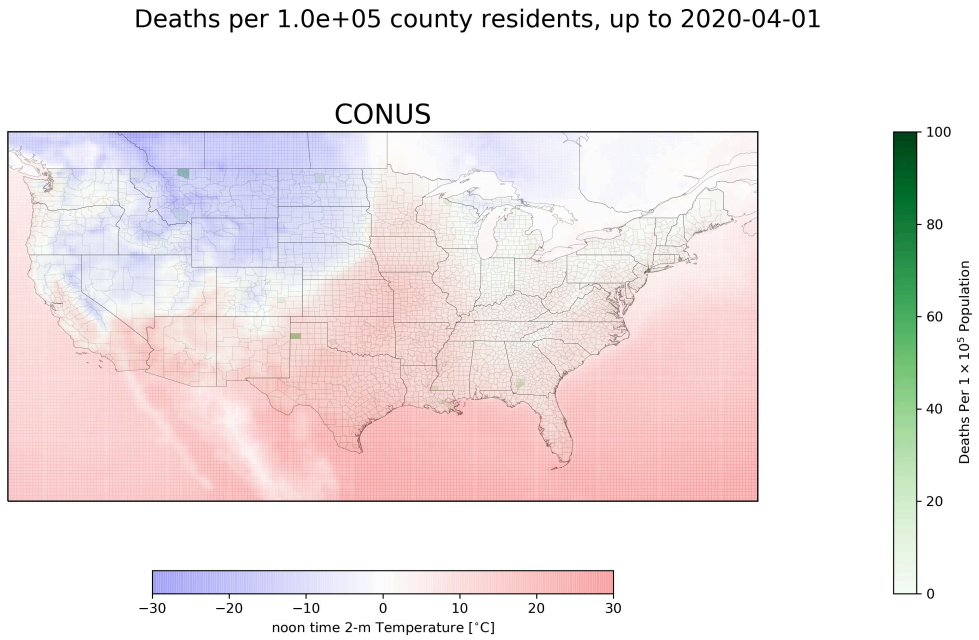
Deconvolving direct and indirect effects of climate variables on COVID-19 seasonality

Challenge: Environmental factors like temperature, humidity and UV can directly and indirectly influence COVID-19 transmission and infection – will there be seasonal re-occurrence and can we predict it?

Approach: Integration of county level climate, epidemiology, behavior (smartphone mobility), demographics with advanced Machine Learning.

Outcome: Mechanistic connection between climate and disease transmission to improve predictive models and public health planning

Data sources: *New York Times*, CDC, Bin Yu (UCB Statistics), ECMWF, SafeGraph, Open Census Data, Google Earth Engine



Berkeley Lab Team
PI: Eoin Brodie. Co-PIs James (Ben) Brown, Nicola Falco, Dan Feldman, Zhao Hao, Chaincy Kuo, Haruko Wainwright

Summary

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- Berkeley Lab is participating in a broad national effort to fight the pandemic
- The national user facilities at Berkeley Lab play an important role in this fight
- Researchers at Berkeley Lab have proposed innovative ideas that help us understand the virus, its propagation, and its impact
- During the shelter-in-place order essential research work continued under safe conditions at the lab and at home

Thank You