Very Brief Introduction to:
2017-2027 Decadal Survey for Earth Science and Applications from Space (“ESAS 2017”)

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The consensus study had the primary goal to generate recommendations for the environmental monitoring and Earth science and applications communities for an integrated and sustainable approach to the conduct of the U.S. government’s civilian space-based Earth-system science programs – NASA, NOAA, USGS for – 2017-2027.

The study was organized by the National Academies of Sciences, Engineering, and Medicine, which produced the final report:

**ESAS 2017: Recommendations**

**TABLE 3.3 Observing System Priorities—Observations (Targeted Observables)**

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ESAS 2017: Recommendations

A+CCP has the potential to provide more and better information to characterize the 3-D structure of aerosols within the boundary layer, including to infer surface PM$_{2.5}$ to enable numerous air quality and health applications.

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**ESAS 2017: Science & Applications Priorities**

**Why?**

- **Goal: (W-5: MI)** "What processes** determine the spatiotemporal structure of important air pollutants and their concomitant adverse impact on human health, agriculture, and ecosystems?"

- **Objective: W-5a.** "Improve the understanding of the processes that determine air pollution distributions and aid estimation of global air pollution impacts on human health and ecosystems by reducing uncertainty to <10% of vertically resolved tropospheric fields (including surface concentrations) of speciated particulate matter (PM), ozone (O₃), and nitrogen dioxide (NO₂)."

- **Related to**
  - **(W-1: MI)** "What planetary boundary layer (PBL) processes are integral to the air-surface (land, ocean, and sea ice) exchanges of energy momentum, and mass, and how do these impact weather forecasts and air quality simulations?"
  - **(W-3: VI):** "Influence of Earth surface variations on weather and air quality."
  - **(W-6: I):** "Long-term air pollution trends and impacts."
  - **(C-5a: VI):** "C-5a. Improve estimates of the emissions of natural and anthropogenic aerosols and their precursors via observational constraints."

**Processes** include chemical and dynamic ones, such as boundary layer mixing & venting (+ W-1 & W-3 variables), emissions (C-5a), gas-to-particle conversion, long-range transport, etc.
Strong Applications Focus in ESAS 2017

**Earth Information is Increasingly Critical to Thriving on our Planet**

- Weather Forecasts, Modeling, Severe Weather Outlooks, Mitigating High Impact Events
- Exposure Estimates, Pollution Mitigation, AQ Forecasts
- Rainfall + Disease

**The Importance of Earth Information**

- Earth-observing satellites provide critical information about our planet. This information supports a broad range of societal needs and enables the scientific discovery required to meet these needs, making us all healthier, safer, and more efficient.

**Helping Plan Our Day**

- 300 billion weather forecasts used by Americans every year
- 100+ million Americans use internet-based mapping services

**Protecting Our Health**

- 6.5 million premature deaths from air pollution around the world every year
- 50% of the world’s population is at risk from malaria

**Keeping Us Secure**

- The estimated value of NASA and NOAA information services to the U.S. Navy’s operational effectiveness is $2 billion per year.
- The U.S. Navy and other U.S. defense agencies partner with NASA and NOAA to use satellite data, to access operational services, and to leverage their scientific progress.

**Mitigating Natural Disasters**

- Extreme weather and floods cost the federal government more than $350 billion over the past decade.
- Satellite measurements play a critical role in tracking the paths of hurricanes and wildfires so that we can warn populations, assess the damage, and assist recovery efforts.

**Ensuring Resource Availability**

- Advanced technology, including many types of Earth information, will unlock up to $1.6 trillion in economic savings for energy generation and use by 2035.
- Satellite observations can also help ensure water availability, which is particularly important to the 20% of the world facing chronic or acute water scarcity.

From Decadal Survey press conference, January 2018

**National Defense, Mission Planning, Response**

**Floods, Drought, Wildfires, Volcanos, Landslides**

**Water Resources, Solar Energy**
Enabling New Stakeholders: Gridded Products

How can the A-CCP design (e.g., orbit, sensor suite) facilitate the creation of Level 3 & 4 gridded products?

- Novice
- Intermediate
- Sophisticated

Gridded Rain Rate
Gridded Particulate Matter

- Novice (L3/L4) e.g., Operational Users, IBM
- Intermediate (L2-L4) e.g., Human Health, Private Industry, AQ Managers
- Sophisticated e.g., Big Data, Some Resource Managers, Modeling Communities
Enabling New Stakeholders: Gridded Products

Example: Randall Martin's Group at Dalhousie University created a Level 4 "nose-level" particulate matter (2.5 µm) product, which is being used by the health community for exposure assessments, etc.

Surface PM (1998-2016 Average)

Satellite Data (MODIS, MISR, SeaWiFS) + Atmospheric Model

Van Donkelaar et al. (2018)
Examples of AOD to PM Conversion

**Global scale (10 km, temporally averaged)**
e.g. Van Donkelaar et al., *Environ. Health Perspect.* [2015]

They infer PM$_{2.5}$ from a combination of passive satellite observations (from *SeaWIFS*, *MISR*, *MODIS*) and Chemistry Transport Model (*GEOS-Chem*)

Evaluation using ground stations outside Canada, US and Europe: significant agreement (R=0.81) but satellite derived PM2.5 is biased low

**Urban scale (1-4 km)**
e.g. Hu et al., *Remote Sens. Env.* [2014]

They infer PM$_{2.5}$ from *MODIS-MAIAC AOD*, a two-stage spatial statistical model, meteorological fields and land use parameters