



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

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THRIVING ON OUR CHANGING PLANET

A Decadal Strategy for Earth Observation from Space



Purpose of ESAS 2017

- 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:
 - *Full report:* National Academies of Sciences, Engineering, and Medicine (2018). Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space. Washington, DC: The National Academies Press. <https://doi.org/10.17226/24938>, 2018).

ESAS 2017: Recommendations

TABLE 3.3 Observing System Priorities—Observations (Targeted Observables)

Targeted Observable	Science/Applications Summary	Candidate Measurement Approach	Designated Explorer	Incubation
Aerosols	<i>Aerosol properties, aerosol vertical profiles, and cloud properties</i> to understand their effects on climate and air quality	Backscatter lidar and multichannel/multiangle/polarization imaging radiometer flown together on the same platform	X	
Clouds, Convection, and Precipitation	<i>Coupled cloud-precipitation state and dynamics</i> for monitoring global hydrological cycle and understanding contributing processes, including cloud feedback	Dual-frequency radar, with multifrequency passive microwave and sub-mm radiometer	X	
Mass Change	<i>Large-scale Earth dynamics</i> measured by the changing mass distribution within and between Earth's atmosphere, oceans, groundwater, and ice sheets	Spacecraft ranging measurement of gravity anomaly	X	
Surface Biology and Geology	<i>Earth surface geology and biology</i> , ground/water temperature, snow reflectivity, active geologic processes, vegetation traits, and algal biomass	Hyperspectral imagery in the visible and shortwave infrared; multi- or hyperspectral imagery in the thermal IR	X	
Surface Deformation and Change	<i>Earth surface dynamics</i> from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	X	
Greenhouse Gases	<i>CO₂ and methane fluxes and trends</i> , global and regional with quantification of point sources and identification of sources and sinks	Multispectral shortwave IR and thermal IR sounders; or lidar*	X	
Ice Elevation	<i>Global ice characterization</i> including elevation change of land ice to assess sea-level contributions and freeboard height of sea ice to assess sea ice/ocean/atmosphere interaction	Lidar*	X	
Ocean Surface	<i>Coincident high-accuracy currents and vector winds</i>	Doppler scatterometer		

ESAS 2017: Recommendations

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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.

Overview of Current & Future Program of Record
Aaron Naeger

Overview of A-CCP
Arlindo da Silva

Overview of A-CCP Applications
Ali Omar

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?"

What?

- **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

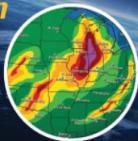
THE IMPORTANCE OF EARTH INFORMATION

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 those needs, making us all healthier, safer, and more efficient.

HELPING PLAN OUR DAY

300 billion

weather forecasts used by Americans every year



100+ million

American adults use internet-based mapping services



Americans rely on sophisticated Earth information throughout their everyday lives, from weather forecasts to navigation applications in their cars. Satellites are the original sources of much of the data.

PROTECTING OUR HEALTH

6.5 million

premature deaths from air pollution around the world every year



Earth-observing satellites track the concentration of harmful pollutants across the country, providing air quality data for rural areas without ground-based monitoring systems and measuring the effects of air quality regulations.

50% of the world's population is at risk from malaria.

Satellite observations of temperature, vegetation, and rainfall help predict the spread of mosquito-borne illnesses like malaria, Zika, and West Nile Virus.



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 fires have 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 at risk, assess the damages, and avoid future costs.



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 now living in areas of water scarcity.



National Defense, Mission Planning, Response

Floods, Drought, Wildfires, Volcanos, Landslides

Water Resources, Solar Energy

From Decadal Survey press conference, January 2018

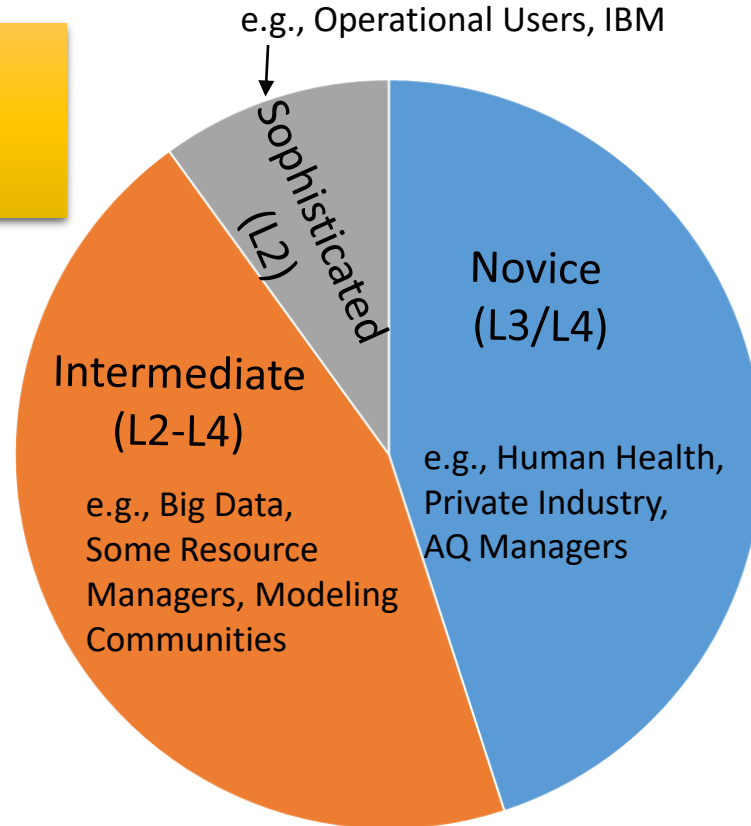
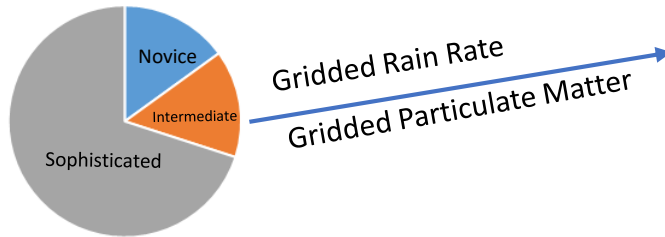
Weather Forecasts, Modeling, Severe Weather Outlooks, Mitigating High Impact Events

Exposure Estimates, Pollution Mitigation, AQ Forecasts

Rainfall + Disease

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 ?

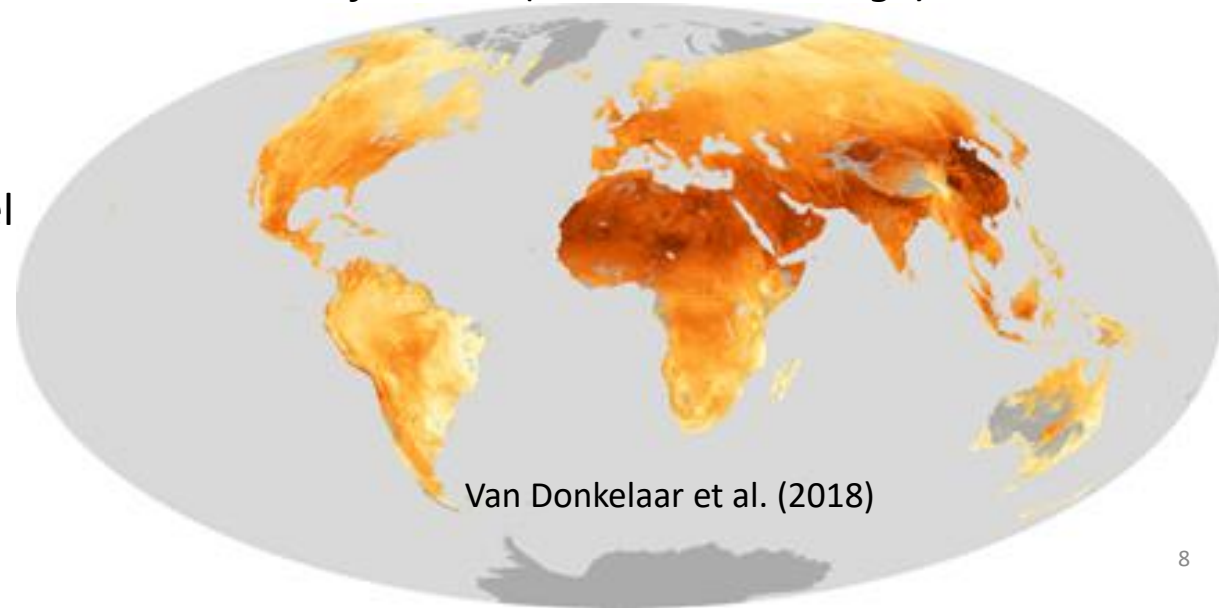


Enabling New Stakeholders: Gridded Products

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

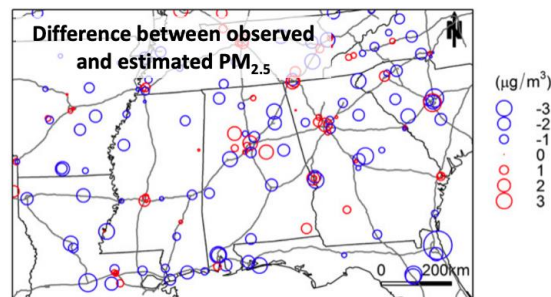
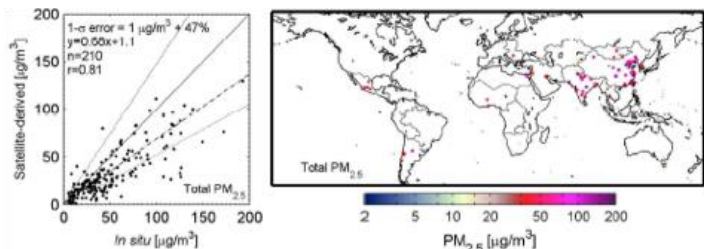
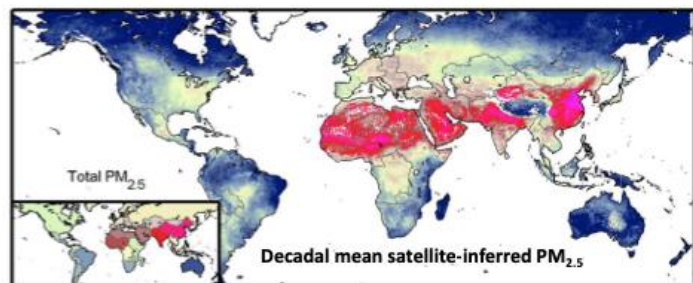
Satellite Data (MODIS, MISR, SeaWiFS) + Atmospheric Model

Surface PM (1998-2016 Average)



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 PM_{2.5} 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