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

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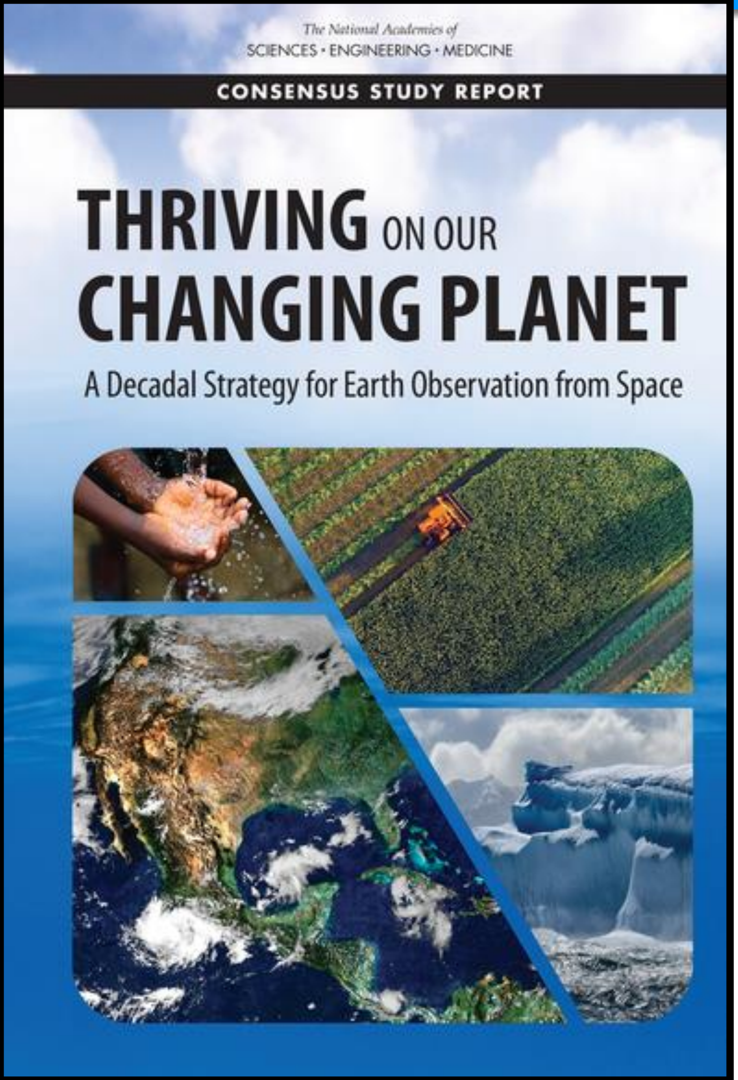

Purpose of ESAS 2017

- 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	*Aerosol properties, aerosol vertical profiles, and cloud properties* 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	*Coupled cloud-precipitation state and dynamics* 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	*Large-scale Earth dynamics* 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	*Earth surface geology and biology*, 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	*Earth surface dynamics* from earthquakes and landslides to ice sheets and permafrost	Interferometric Synthetic Aperture Radar (InSAR) with ionospheric correction	X		
Greenhouse Gases	*CO_2 and methane fluxes and trends*, 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	*Global ice characterization* 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	*Coincident high-accuracy currents and vector winds*	Doppler scatterometer			

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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 (O_3), and nitrogen dioxide (NO_2)."

- ***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

?

From Decadal Survey press conference, January 2018

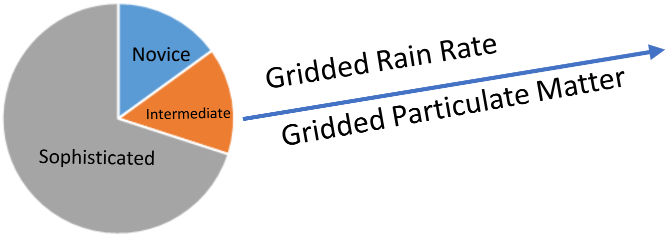
National Defense, Mission Planning, Response

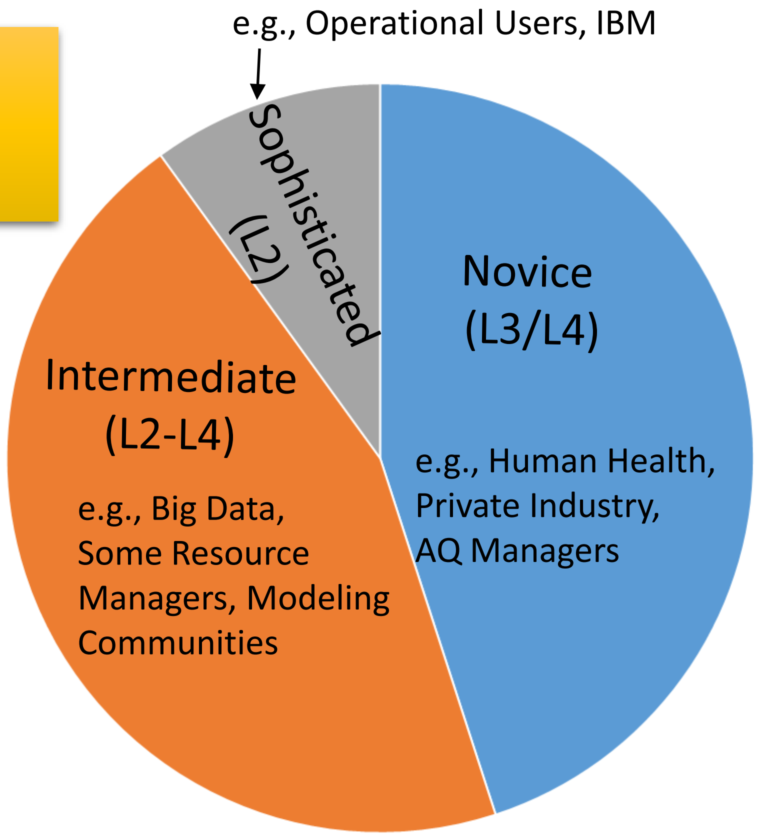
Floods, Drought, Wildfires, Volcanos, Landslides

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 ?



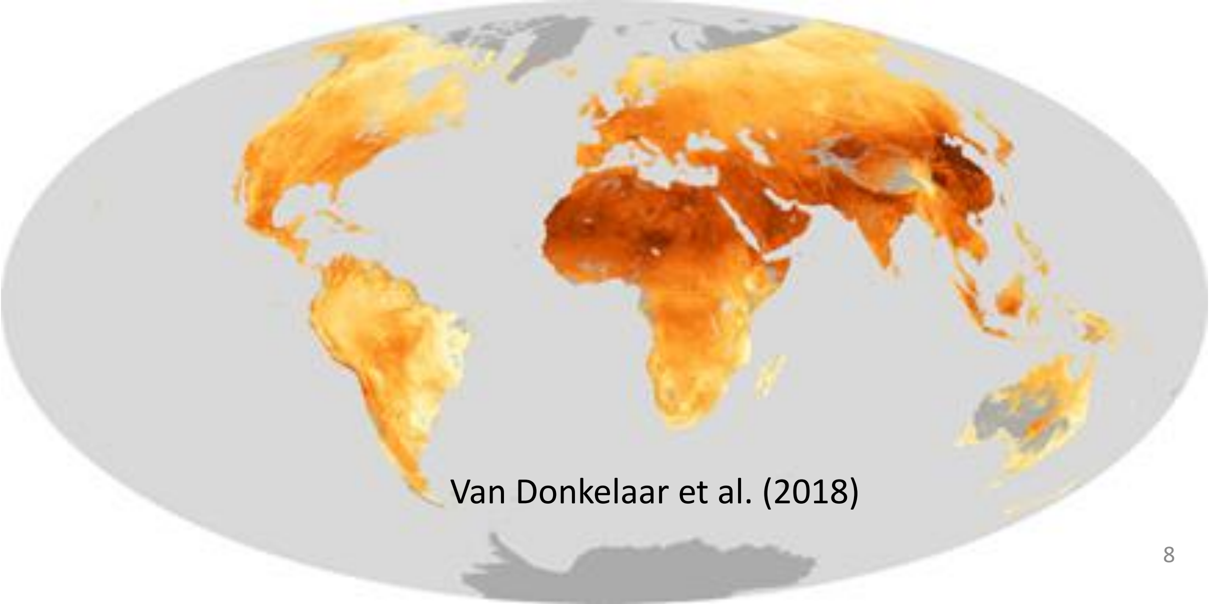


Enabling New Stakeholders: Gridded Products

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.

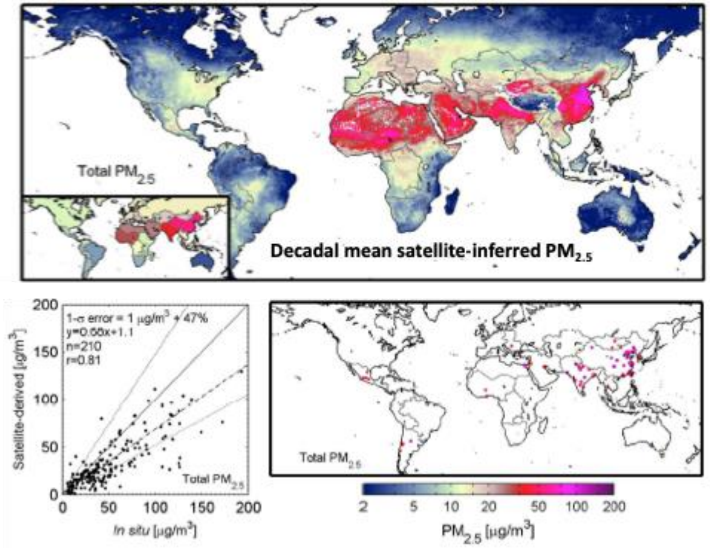
Satellite Data (MODIS, MISR, SeaWiFS) + Atmospheric Model

Surface PM (1998-2016 Average)



Van Donkelaar et al. (2018)

Examples of AOD to PM Conversion

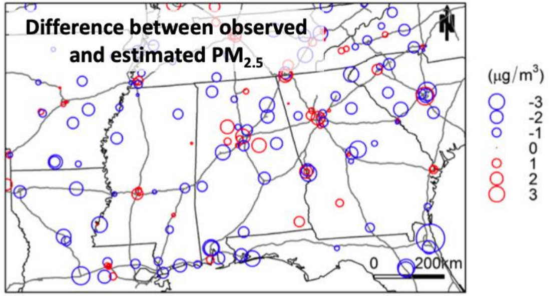


Global scale (10 km, temporally averaged)

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 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