ATMOSPHERE
Observing System

National Aeronautics and Space Administration

EARTH SYSTEM OBSERVATORY

Lessons Learned From AOS

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Earth System Observatory
Atmosphere Observing System

Outline

Topics
Establishing requirements
The importance of applications
Identifying available technologies
Cost considerations and trades
Key challenges for PBL

Earth System Observatory
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Establishing Requirements

- For science requiring synergistic measurements (multiple instruments seeing the same scenes at the same time), DS whitepapers should be explicit in such a recommendation
- Keep threshold science scope & requirements realistic; transformational science is exciting but expensive; make sure to identify a descope strategy from Baseline to Threshold
- Avoid lines in the sand, i.e., saying that without some major advancement the science is not worth doing
- Define a realistic threshold; don't define one that you may eventually have to backtrack from

Goal	Science Questions	Geophysical Variables and Measurement Requirements	Potential Measurement Technologies from Space
G2. Cloudy PBL	**Q2.1**: How do the PBL thermodynamic structure and cloud properties covary and interact with each other, and how does it depend on cloud type? **Q2.2**: How are these PBL-cloud interactions mediated by turbulent surface fluxes and overlying free tropospheric thermodynamic conditions? **Q2.3**: What is the role of mesoscale variability in modulating the vertical structure of the cloudy PBL temperature and water vapor?	• **T** and **q** profiles (in PBL and free troposphere) with high vertical resolution (100-200 m) in clear and cloudy conditions • **T** and **q** profiles at horizontal resolutions as in G1 • PBL height • Cloud properties (synergistic measurements) • Radiative fluxes (synergistic measurements) • Surface fluxes (based on synergistic measurements)	**Horizontal resolution as in G1:** Combination of IR, MW and SW. **Vertical resolution:** • DIAL measures **q** profiles, 200 m vertical resolution from space in clear sky (2D curtain) • DAR measures **q** profiles, 200 m vertical resolution from space in cloudy sky (2D curtain) • GNSS RO measures **T** or **q** profiles with 100 m vertical resolution from space (scattered sampling)

Establishing Requirements

- To an outside observer, the synergistic measurements (PoR?) appear to be key drivers of differences in goals
- What are the sources of those synergistic data sets?

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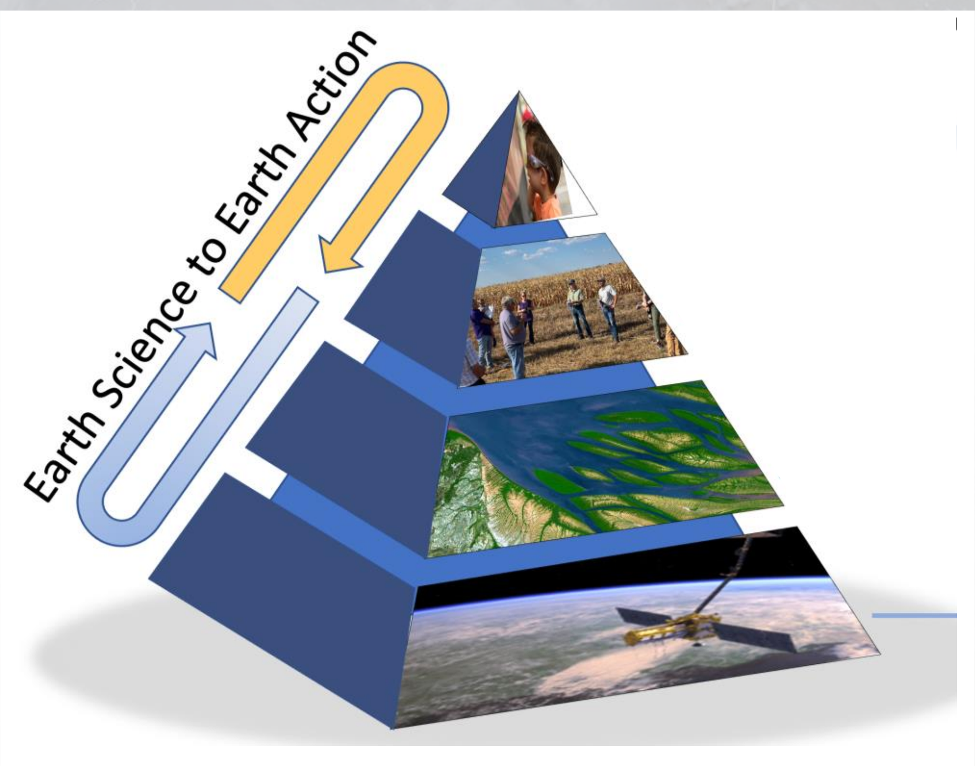
The Importance of Applications

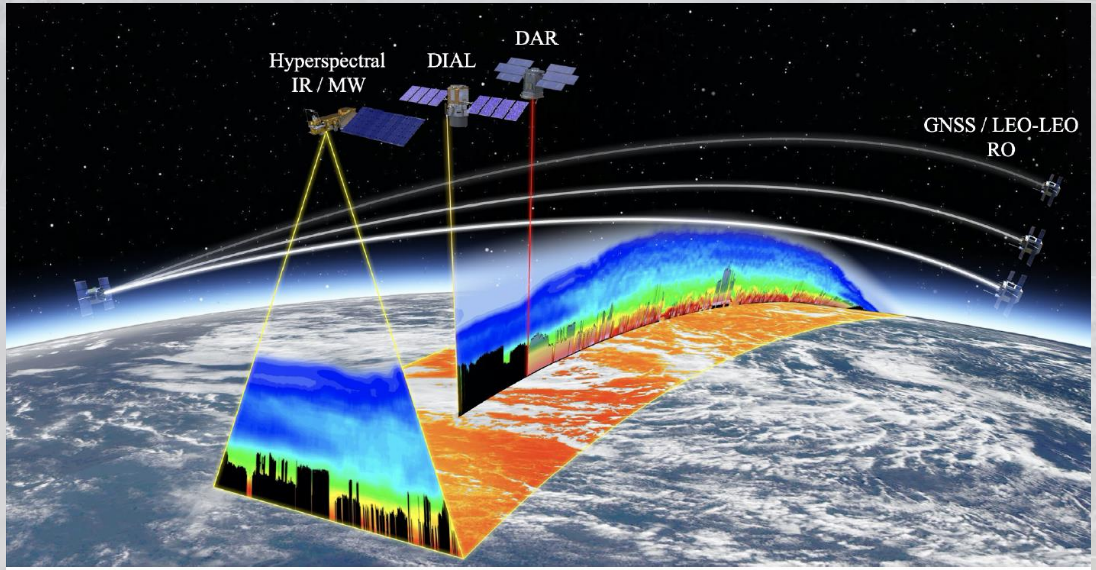
- Need to make the case for how the mission contributes to Earth Action
- Consider applications early and, where possible, demonstrate through solid examples or quantitative assessments
- Take the example all the way down to the public user; this strategy may encourage users to advocate for the mission
- Understand your latency requirements and whether they are achievable



Credit: NASA SVS

Identifying Available Technologies

- RFI-based library of capabilities useful
- Have a range of capabilities represented
- Beware the "advanced/smallsat technology makes it cheaper" argument
- Prioritize science measurements & sensors



From NASA PBL Incubation Study Team report

Cost Considerations and Trades

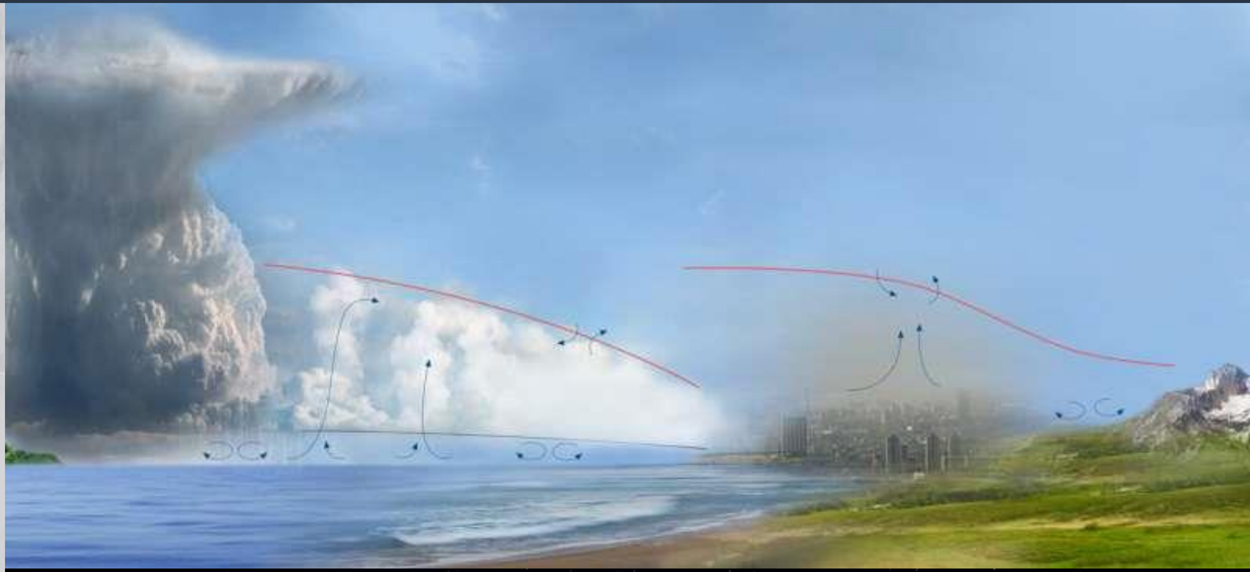
- Fully understand budget assumptions, i.e., content, desired cost confidence, reserves, (including HQ UFE), etc.
- Use multiple cost models but beware of estimates substantially lower than parametric models
  - Instrument cost estimates grow considerably during preformulation
- Expect total cost to be ~3-4 times the total instrument cost
- Respect the cost cap; consider more conservative cost estimates for added margin
- Be realistic about TRL & time needed to reach TRL6
  - Viable instrument concepts likely need to be at TRL5 by ~2030, with clear path to TRL6; otherwise cost and schedule risk will be high
- Have well-defined descope options that get you well below the cap

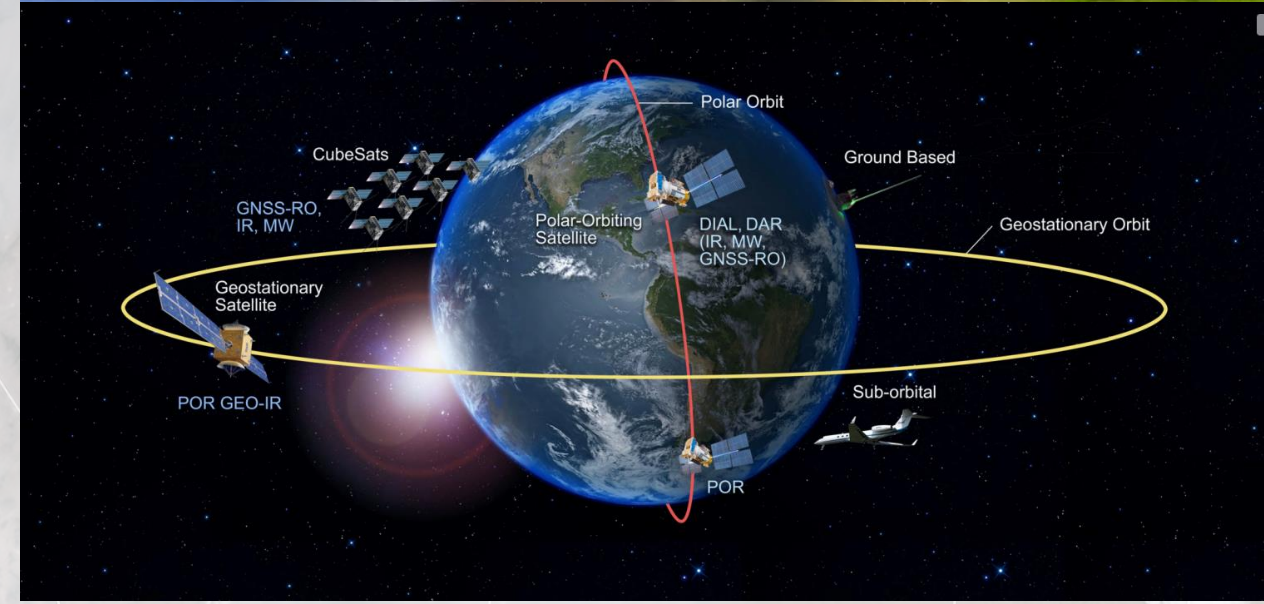
Other Factors Affecting Cost

- Single vs disaggregated platforms?
  - Disaggregated architectures may increase cost, operational and science complexity, but improve programmatic flexibility
  - AOS moved to ”decouple, partner, and compete” approach
- The DS pointed to synergistic measurements within A and CCP individually and the ACCP study further coupled the science
  - Extensive science activities (orbital, suborbital, modeling) can lead to a large science budget

Key Challenges for PBL

- Large satellite bus for active and passive sensors, HQ preference for disaggregation
- Total instrument cost (esp. actives) may drive major cost issues
- Low TRL of emerging technologies—clear path to TRL6 by early 2030s?





Figures from NASA PBL Incubation Study Team report

Extra slides

Pros and Cons of International Partnerships

- International partnership can add significant value for low cost
- Prioritize partnerships that provide essential measurements, thereby lowering total instrument costs
- Partnerships that provide nice-to-have science can be difficult to eliminate later on

Defining Clear Objectives

- Goals are what you aspire to do, objectives are what you sign up to achieve
- Quantitative objective statements can make evaluations of success easier but can be hard to formulate
  - Determine the profile of aerosol backscatter and aerosol species in clear-sky conditions

  vs

  - Detect X% of aerosol layers of different types (i.e. dust, smoke) in cloud-free conditions with aerosol optical depth ≥0.05
- Can the objectives be prioritized? Prioritization may inform descope options from baseline to threshold.

Value Framework For Architecture Evaluation

- A value framework allows for objective quantitative assessments of architectures
- Value=utility x quality
  - Utility=importance of GV to science objective
  - Quality=accuracy/resolution/sensitivity of retrieved GV for a given sensor or sensor set
- Ambiguity can enter in when factoring in sampling (diurnal vs global/statistical sampling)
- Quantifiable objectives better than non-quantifiable
- Don’t make objectives too broad and overlapping
- If objectives flow to nearly identical GV requirements, then there is no distinction between them
  - For example, the distinction between the PBL objectives appears related more to synergistic data sources than T, q

Earth System Observatory

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Value Framework Concept

Clouds Precip Aerosols Dynamics

Objective	Geophysical Variables (GVs)	Sensors Types
PBL, convection, and extreme weather	Distributions of T and q, clear and cloudy (0.5-1 km vertical, 1 km horizontal), PBL height	IR sounding, MW sounding, SW obs, DIAL/DAR
(	Distributions of T and 0-200 m vertical, 1 km horizontal), PBL he properties, radiative flux , surface fluxes	Co DIA
I i	and 0-2 (la avg minimum), eight, properties, near surfa properties	Co DIA D
I and air quality	Distributions of T and 0-200 m vertical, 1 km horizontal), PBL height; synergistic cloud properties, radiative fluxes, PBL winds	Co DIAL, DAR, and/or GNSS RO PBL height from T, q, clouds, or aerosols

…and lead to success in meeting science objectives?

Utility

…impact derived geophysical variables

Quality

How do changes in sensor capabilities

Dependence on synergistic data sets complicates utility assessment unless fixed synergistic products assumed

Narrow set of geophysical variable requirements (T, q profiles; PBL height) simplifies quality assessment

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Diurnal sampling

- Achieving diurnal sampling depends on temporal and spatial scales
  - Smaller spatial/temporal sampling requires either multiple polar observatories or a highly inclined orbit to build reasonable sample sizes and avoid aliasing in seasonal variations
- Days to complete diurnal cycle on smaller regional scales:
  - 65°: 80-85
  - 60°: 70-75
  - 55°: 65
  - 50°: 60
  - 45°: 55
  - 40°: 50
  - 35°: 45-50

"observations cannot be averaged over more than a couple of months without contaminating time-mean properties with seasonal variations"

(Salby & Callaghan 1997)