



National Aeronautics and
Space Administration

NASA earth

Atmospheric Thermodynamics / Dynamics Breakout 1

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Thermodynamics/Dynamics Breakout

1. Summarize the input you as a community have provided
2. Input from presenters (8 total)
3. Discussion



Overview of 28 Survey Responses



1. Planetary Boundary Layer (Pre)

- **Observational Needs:** High-resolution vertical profiling of temperature and water vapor (humidity), capture the diurnal cycle of the PBL.
- **Convective Initiation:** understand how the pre-convective environment evolves. Relative role of PBL forcing versus mid-to-upper level forcing in triggering storms and severe weather hazards.
- **Thermodynamic Coupling:** There is a need to better integrate thermodynamic (T/q) and dynamic (wind) profiles, as these are often treated separately in current observing systems but are physically coupled in the boundary layer.



1. Planetary Boundary Layer (Plenary)

- Convective entrainment/detrainment are critical for understanding the exchange of heat, moisture, and aerosols between the PBL and the free atmosphere, as well as the Upper Troposphere-Lower Stratosphere (UTLS).
- There is a need for more focus on how the land surface impacts the PBL on seasonal to sub-seasonal timescales, rather than just daily variability.
- Need for a clear "target scale and range" for defining PBL height, which currently varies widely across detection methods.
- Need to include surface and airborne observations in PBL measurement system



2. Extreme Weather Events (Pre)

- Examples: heatwaves, droughts, severe thunderstorms, winter storms, atmospheric rivers, hurricanes
- How latent heat release affects the formation and intensification of extratropical cyclones and Atmospheric Rivers (ARs).
- Interaction between severe weather and land surface properties (soil moisture, temperature) and aerosols (e.g., hurricane-dust interactions).
- How precipitation processes at the convective scale feedback into larger mesoscale and synoptic-scale storm dynamics. Role of convection in winter storms.



2. Extreme Weather Events (Plenary)

- Importance (and challenge of) cloud microphysics as drivers of severe weather
- Entrainment/detrainment in convection – a critical need, but challenging to determine how good is “good enough”
- Multiscale interactions between the tropics and extratropics
- Potential for geostationary microwave to provide transformational measurements
- Lightning as a key part of extreme weather and an opportunity for new process level discovery
- Potential afforded by B777 to observe evolution of severe weather over a region over several hours



3. Atmospheric Dynamics and Wind (Pre)

- Multiple responses emphasized the requirement for global 3D wind vector observations (both line-of-sight and horizontal/vertical) to improve predictability for midlatitude high-impact weather.
- Understanding air-sea interactions is a priority, specifically how surface wind stress, convergence, and vorticity supply energy for the upscale growth of convection.
- Need to better understand changes in northern and southern hemisphere stratospheric circulation, and how these changes impact global atmospheric composition and heat transport.



3. Atmospheric Dynamics and Wind (Plenary)

- There was a perceived over-emphasis on small-scale, fast-evolving processes in the earlier responses.
- Participants highlighted a lack of discussion regarding very large- (planetary-)scale waves and their role in the subseasonal-to-seasonal (S2S) gap.
- The role of stratospheric dynamics in improving subseasonal predictions. Modern models still show persistent (and sometimes worsening) biases in stratospheric transport and circulation (e.g., Hadley Cell trends) that need to be addressed.
- Need better understanding of how tropical moisture and energy transport fuel mid-latitude extreme weather.
- Winds are crucial for understanding composition and GHGs.



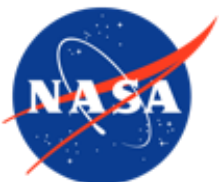
4. Methodologies (Pre)

- **Observation Strategy:** The consensus leans toward a "fleet" or constellation approach (like TROPICS or INCUS) to provide high-temporal revisit rates, which are crucial for observing the rapid intensification of weather features.
- **Synergy and Modeling:** Need for increased investment in:
 - OSSEs (Observing System Simulation Experiments) to inform future mission architectures.
 - Data Assimilation (DA) to utilize the program of record (current satellites) to build a foundation for new missions.
 - AI/ML to bridge spatiotemporal gaps and assist in merging heterogeneous data from active (Lidar/Radar) and passive sensors.



4. Methodologies (Plenary)

- A major concern was raised about the potential loss of the ER-2 high-altitude aircraft. Without it, NASA lacks the capability to fly over deep tropical convection for satellite validation.
- OSSEs should be used as exploratory tools for science and as guardrails for mission design, rather than as justification for mission formulation.



5. Additional Discussion I

- "How good is good enough?": A priority for the next decade is defining the minimum accuracy required for measurements (like entrainment) to increase efficiency and speed progress.
- There is a gap in translating physical process knowledge (rain intensity, wind speed) into statistical risk that insurance companies and FEMA can use.
- Suggest using high-impact weather events to show NASA leadership and stakeholders why uncertainty in dynamics and thermodynamics matters for the space economy (e.g., launch criteria) and national safety.



5. Additional Discussion II

- Role of wave (gravity waves) in the large scale circulation. IR sounders can obtain information on GWs, but there is height ambiguity. From aircraft, we have traditionally looked down, but can also look upward to capture upper troposphere/lower stratosphere. This affords very high resolution in the UTLS (above the “dirty window”)
- For GeoMW, how do we close the technology gap to achieve the channels that are most useful?
- Acknowledge the importance of scale coupling between convective and large scales.



5. Additional Discussion II

- Capability to observe wx from the side does exist from airborne RO. Allows profiling from aircraft altitude to the surface. Does require a specific flight track. Can we leverage commercial receivers (especially with open loop tracking). Small investment with large payoff. Note that B777 has GNSS-RO capability. Note also the strength of polarimetric RO for precipitation.
- Stratospheric balloons have potential to station keep and measure processes. How well can the stratospheric balloons station keep? Suborbital workshop at Johns Hopkins was attended by several companies. Capability of in-situ measuring via suspended cable.
- Solaris as well – uncrewed 60K feet for 12-14 days (X prize for wildfire). Questions about approval for flight tracks and also small payloads (12 kg currently)

