National Aeronautics and Space Administration

Advancing NASA's Climate Strategy

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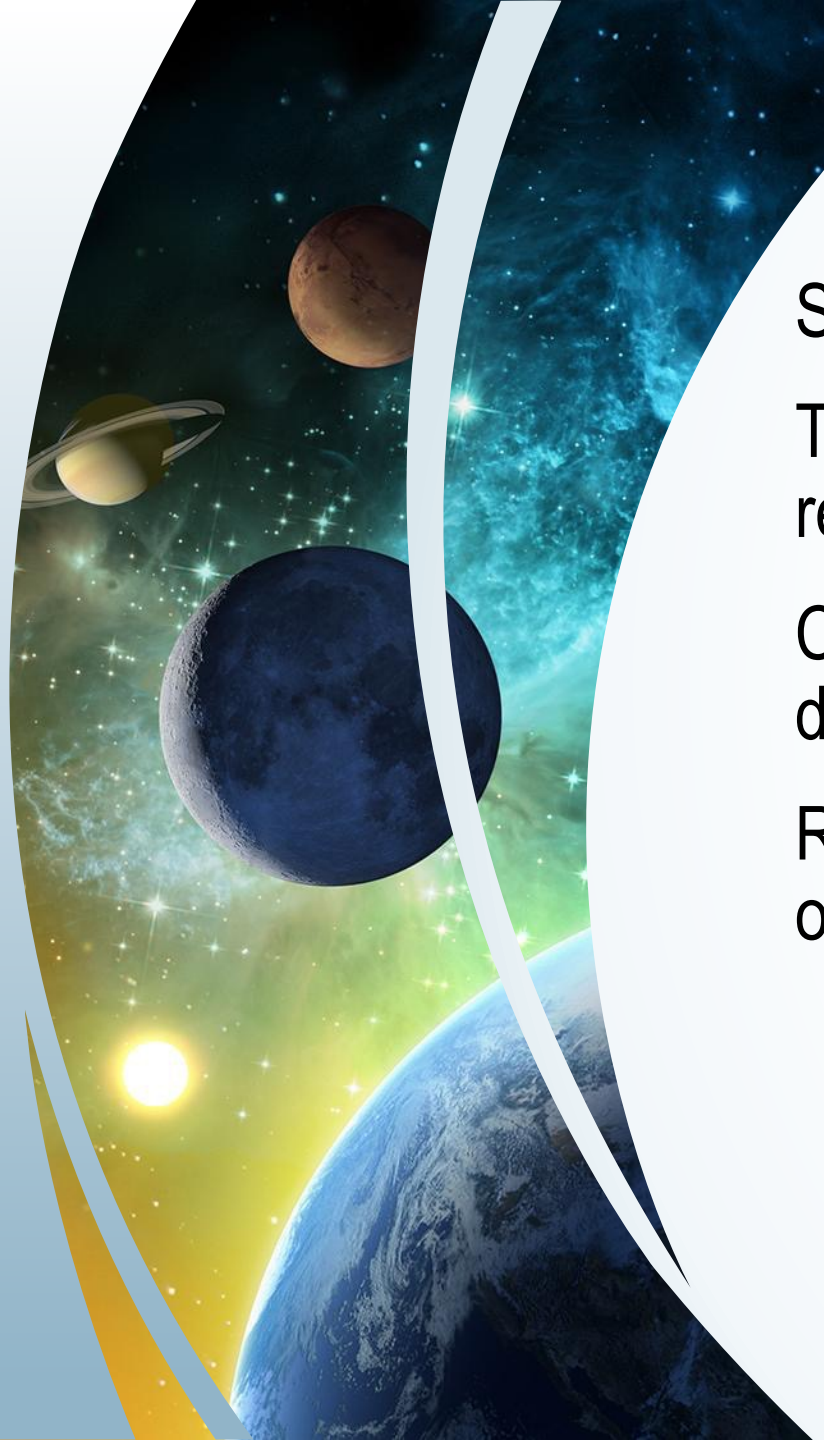
NASA Goddard Institute for Space Science

NASA is mandated to:

- “increase the efficiency of the Nation's air transportation system” & “protect the environment” (51 USC §40102)
- research topics that “can be productively studied from space, including Earth Science & Sun-Earth connections” (51 USC §20301)
- “pursue a program of Earth observations, research, and applications activities to better understand the Earth, how it supports life, and how human activities affect its ability to do so in the future.” (51 USC §60501)
- use practical benefits for society an important measure of the success in addition to securing new knowledge
- ensure the availability and widest possible use of accurate & current data on global warming (51 USC §60506)



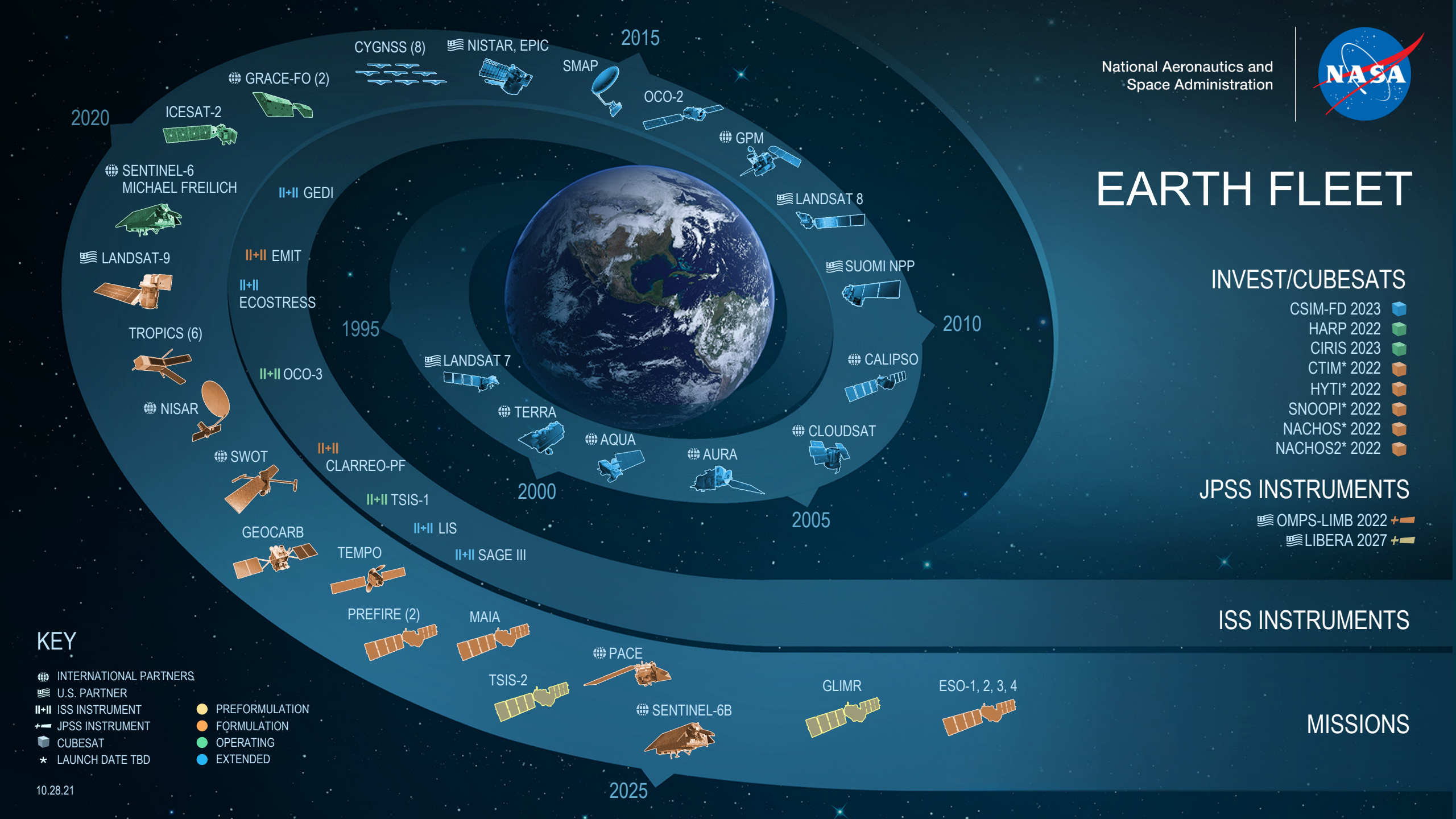
Senior Climate Advisor post created in Feb 2021.

Tasked to assess NASA's climate portfolio and recommend ways to make it better.

Climate Strategy Working Group: cross-division, cross-directorate, cross-center.

Report *"Advancing NASA's Climate Strategy"* in final stage of production

Pillar 1: Observations

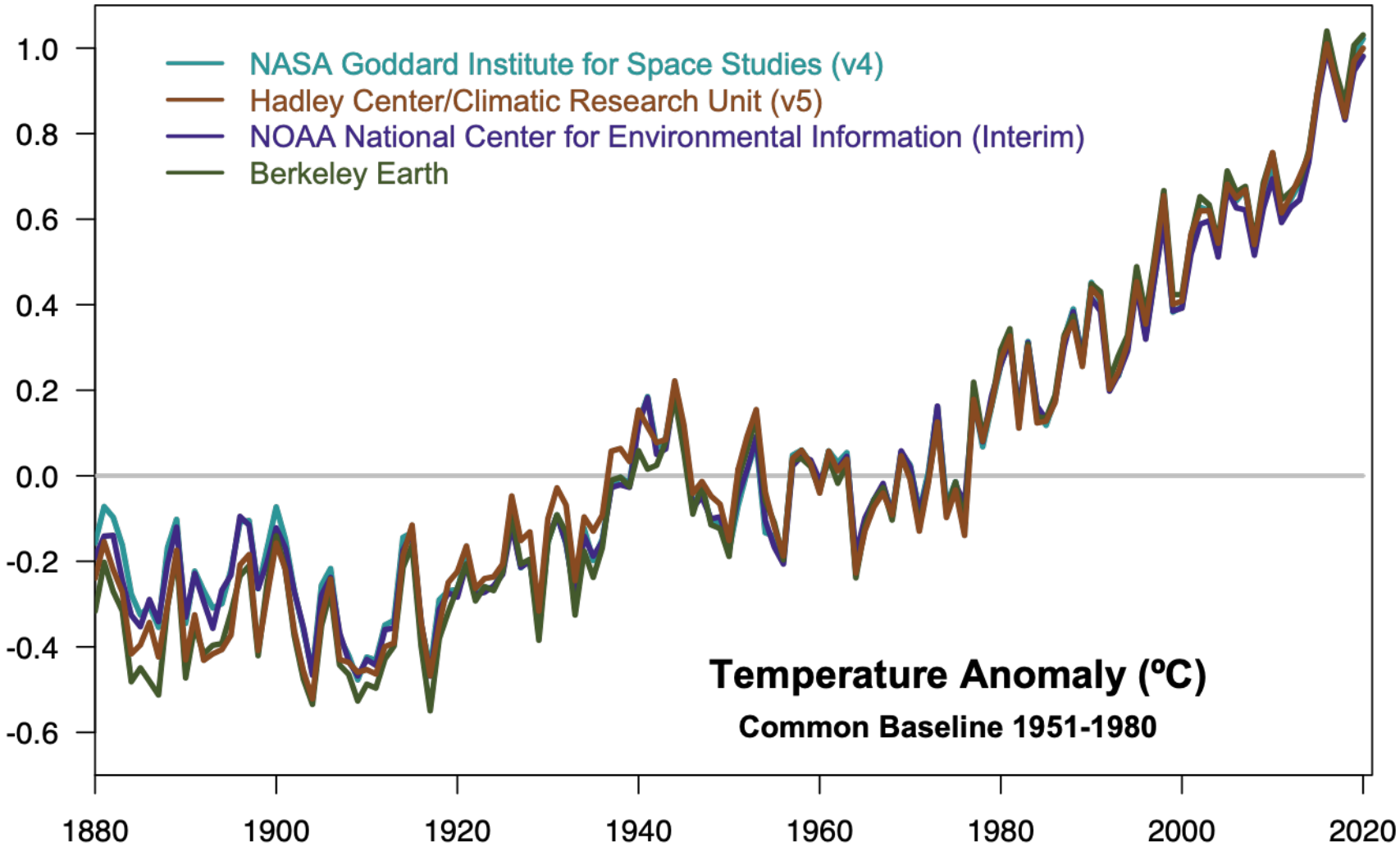

National Aeronautics and Space Administration
NASA
EARTH FLEET
2015
CYGNSS (8)
NISTAR, EPIC
SMAP
OCO-2
GPM
2020
GRACE-FO (2)
ICESAT-2
SENTINEL-6 MICHAEL FREILICH
GEDI
LANDSAT 8
LANDSAT-9
EMIT
ECOSTRESS
SUOMI NPP
2010
1995
TROPICS (6)
LANDSAT 7
CALIPSO
OCO-3
NISAR
TERRA
AQUA
AURA
CLOUDSAT
SWOT
CLARREO-PF
2000
2005
TSIS-1
LIS
GEOCARB
TEMPO
SAGE III
PREFIRE (2)
MAIA
PACE
TSIS-2
SENTINEL-6B
GLIMR
ESO-1, 2, 3, 4
2025
INVEST/CUBESATS
CSIM-FD 2023
HARP 2022
CIRIS 2023
CTIM* 2022
HYTI* 2022
SNOOPI* 2022
NACHOS* 2022
NACHOS2* 2022
JPSS INSTRUMENTS
OMPS-LIMB 2022
LIBERA 2027
ISS INSTRUMENTS
MISSIONS
KEY
INTERNATIONAL PARTNERS
U.S. PARTNER
ISS INSTRUMENT
JPSS INSTRUMENT
CUBESAT
LAUNCH DATE TBD
PREFORMULATION
FORMULATION
OPERATING
EXTENDED
10.28.21

Surface Temperature

- GISTEMP (since 1981)
- Data from 1880

- Weather stations (GHCNv4)
- Ocean buoys/ship data (ERSSTv5)

Warming of 1.2ºC/2ºF since the late 19th Century



Mountain Glaciers

- Landsat (since 1982)
- LandSat 4/5/7/8

- Columbia Glacier, AK

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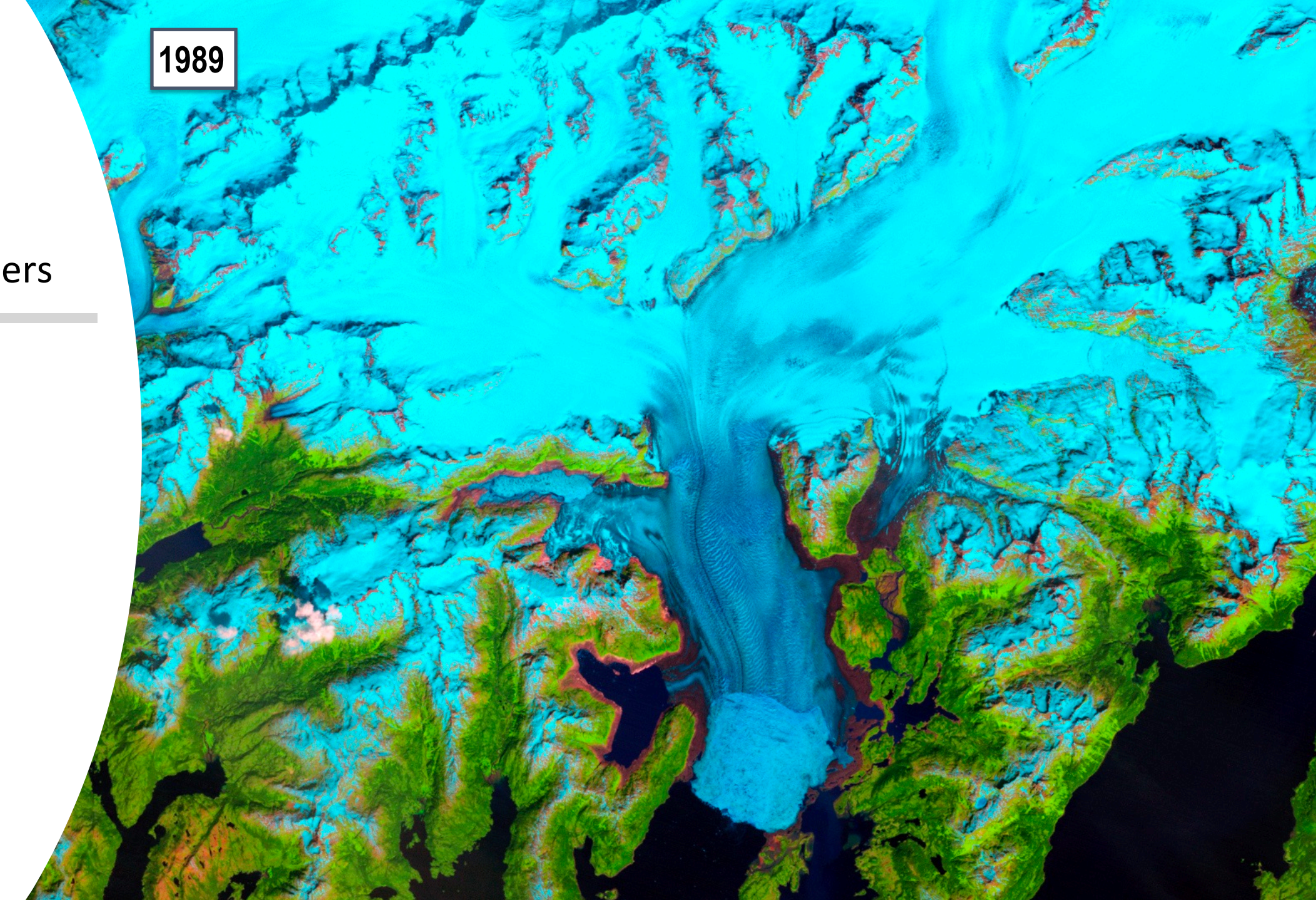
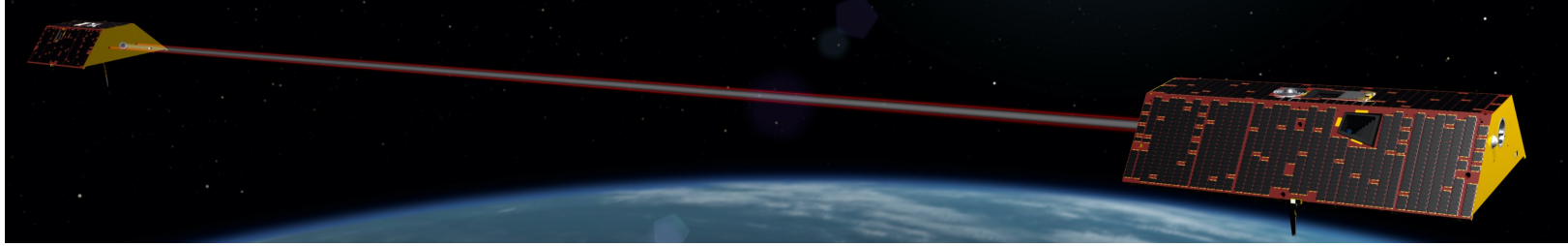
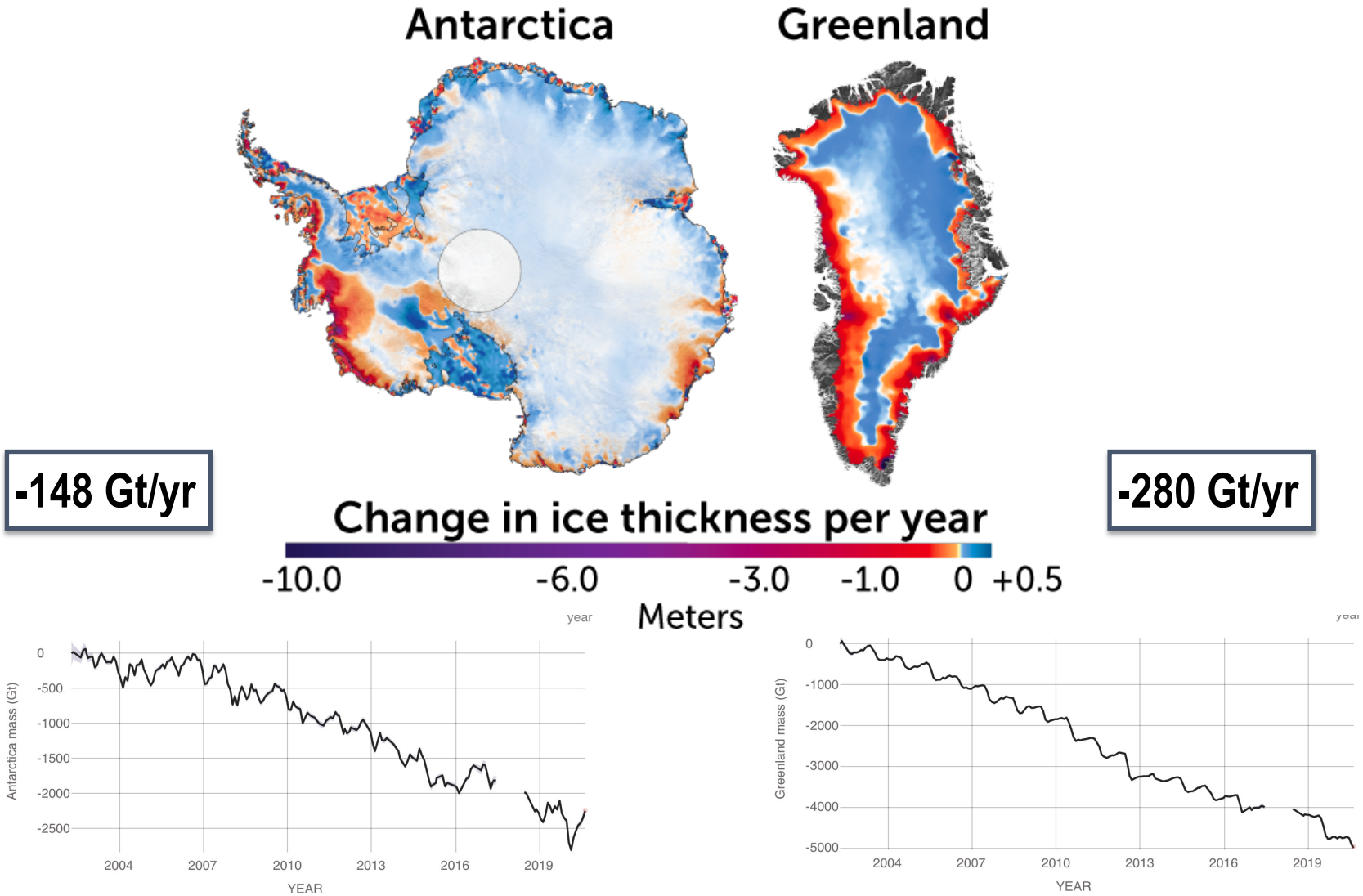


Ice Sheet Mass

- GRACE (2002-2017)
- GRACE-FO (since 2018)

- Trends April 2002-Dec 2020

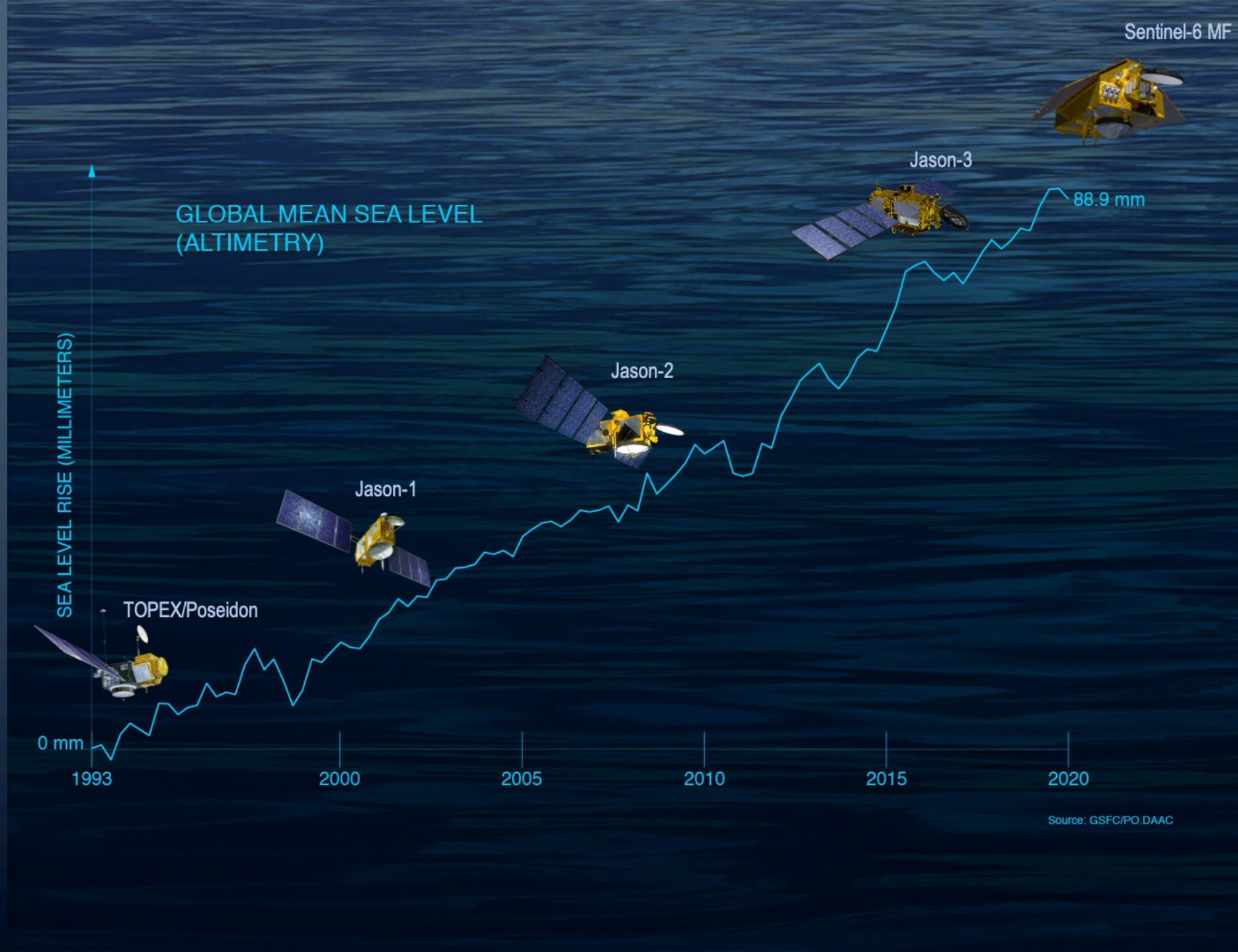




Sea Level Rise

- Since 1993

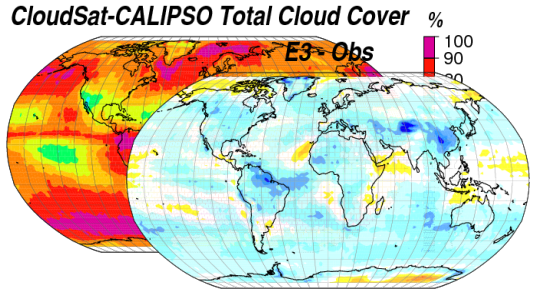
- TOPEX/POSEIDON
- JASON-1
- JASON-2
- JASON-3
- Sentinel-6 Mike Frielich



Pillar 2: Modeling

Climate Models

- Need *process*-level information, boundary conditions, drivers.
- e.g. GISS ModelE, NCAR CESM, GFDL CM, etc.
- Tuning/Calibration best done without looking at trends.

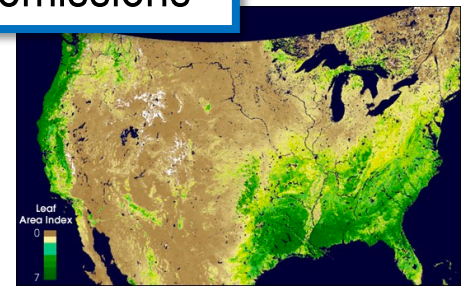


Global and regional evaluation across multiple variables & teleconnections

Model evaluation

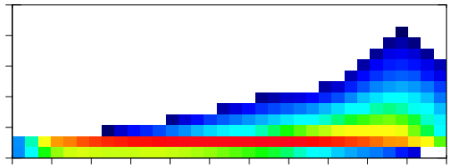
Model inputs

Land surface properties topography, emissions

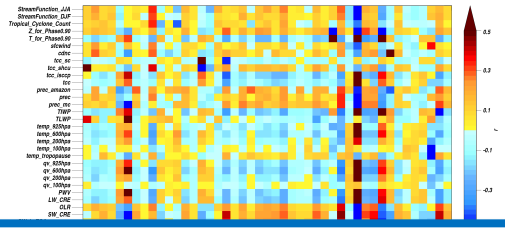


Parameterization development

Process-related diagnostics from low earth orbit and flight campaigns



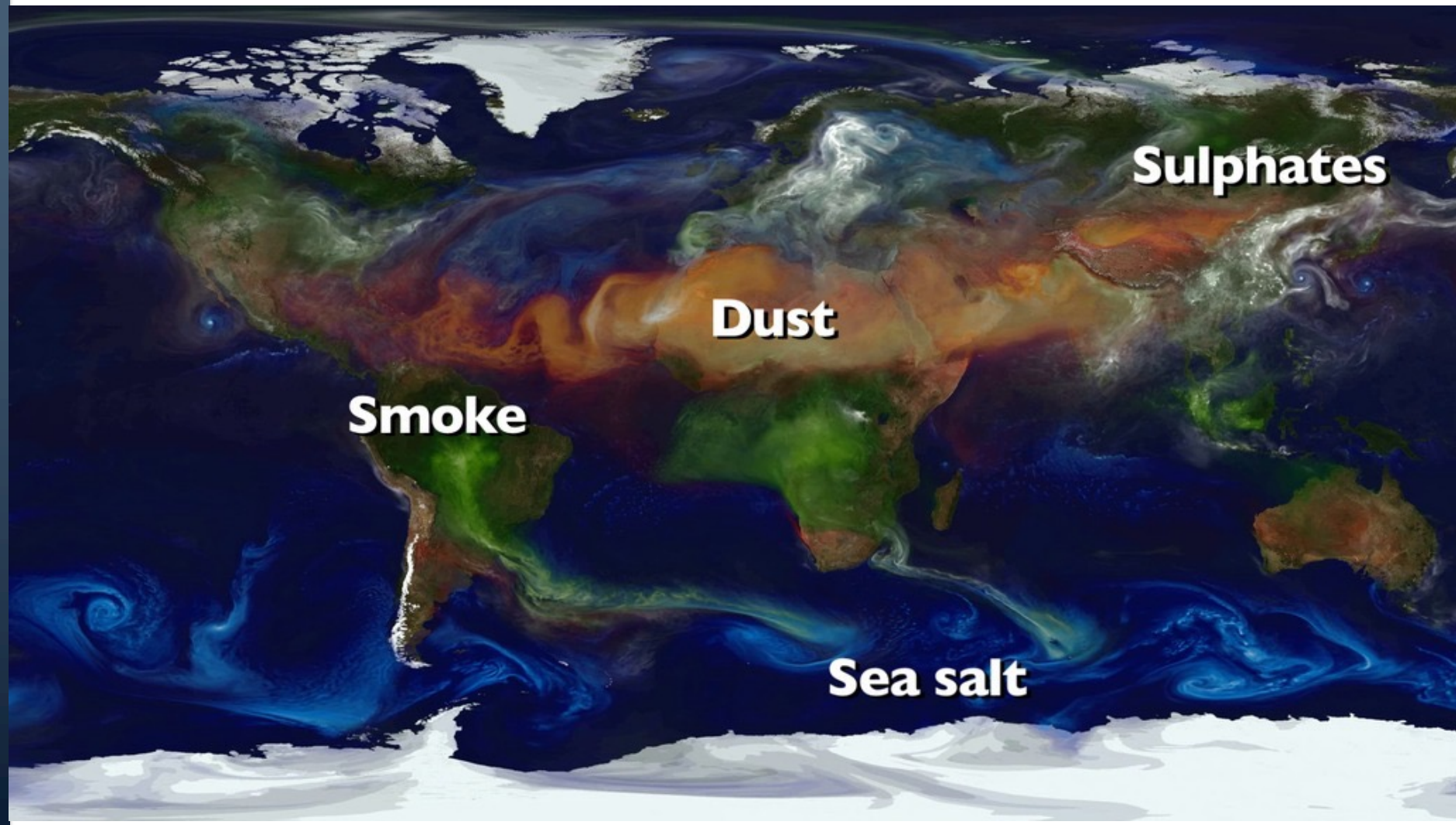
Global tuning



Perturbed physics ensembles plus Machine Learning to match satellite metrics (with uncertainties) across 40+ model parameters

GEOS-5 Reanalysis

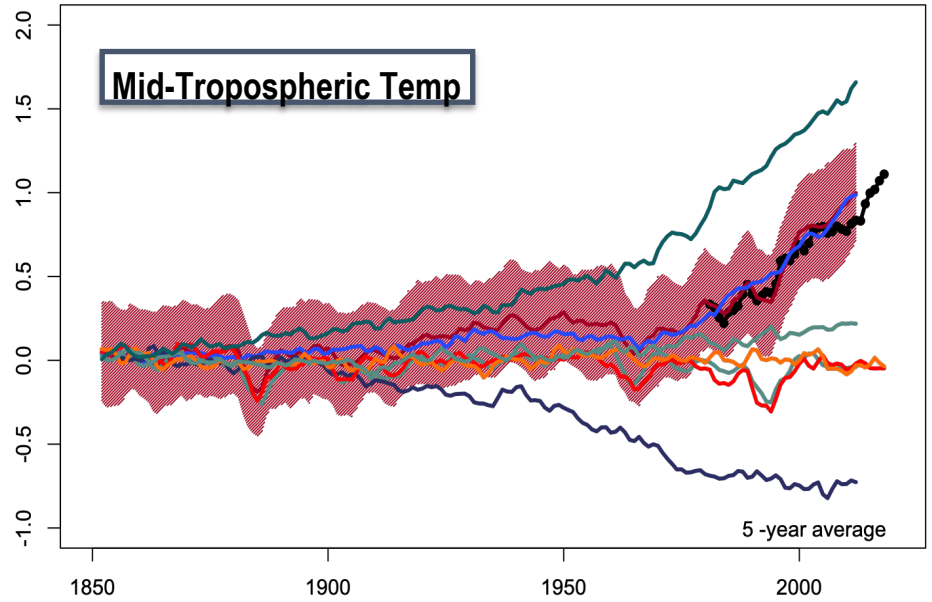
- Weather forecast model run with ingested in situ and satellite data
- Physically consistent atmospheric state, including non-observed variables.

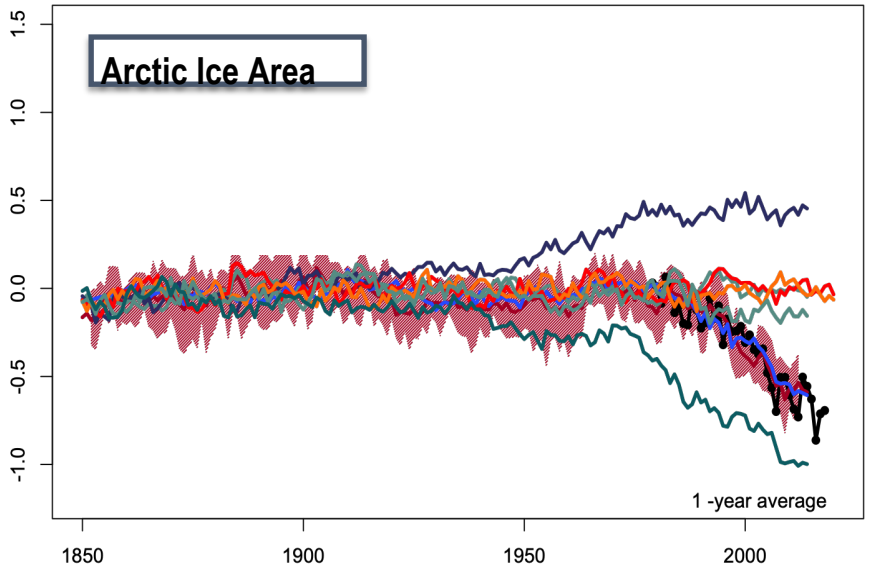


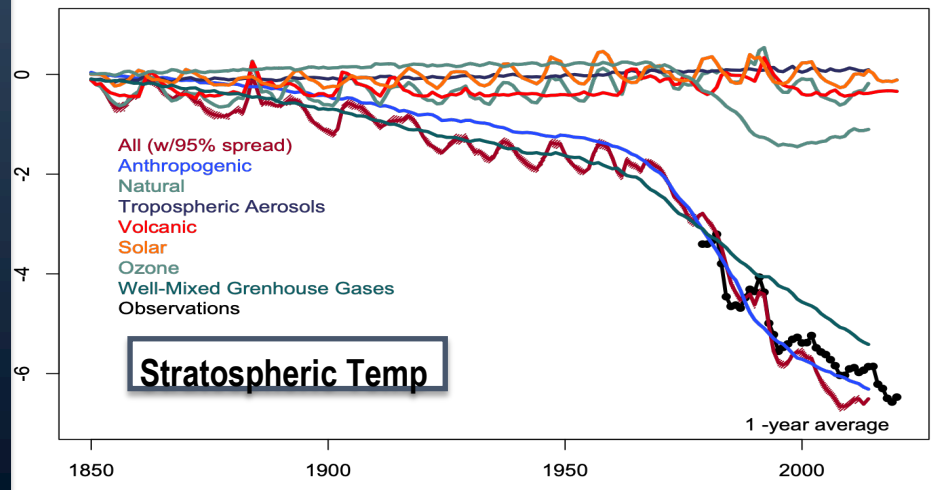
Attribution

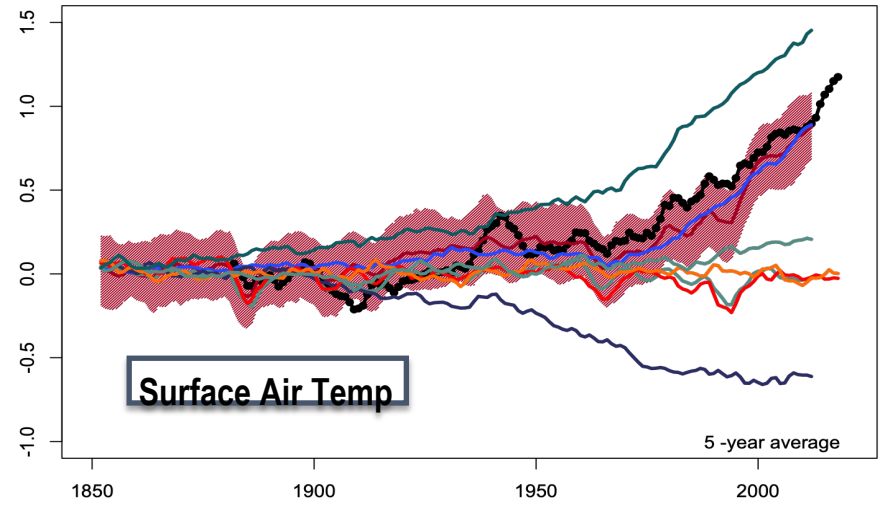
- GISS ModelE2.1 Ensemble simulations with individual drivers, natural-only, anthropogenic-only etc.

- Multi-variate comparisons to observed trends



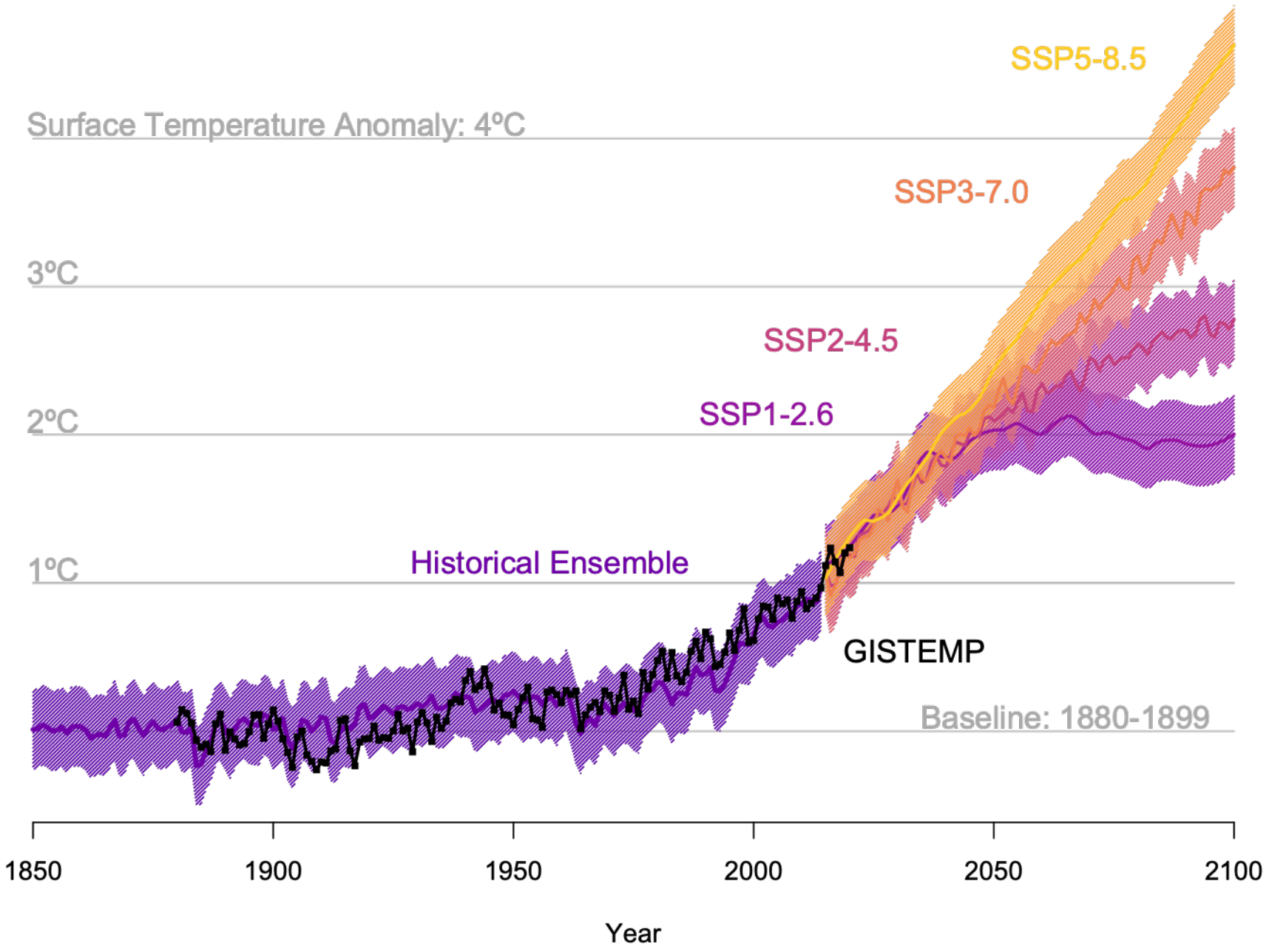






Projections

- Possible futures based on Shared Socioeconomic Pathways
- SSP1-2.6 emission reductions consistent with 2ºC limit
- SSP5-85 ‘burn it all’
- GISS ModelE2.1-G contributions to CMIP6



Downscaled output

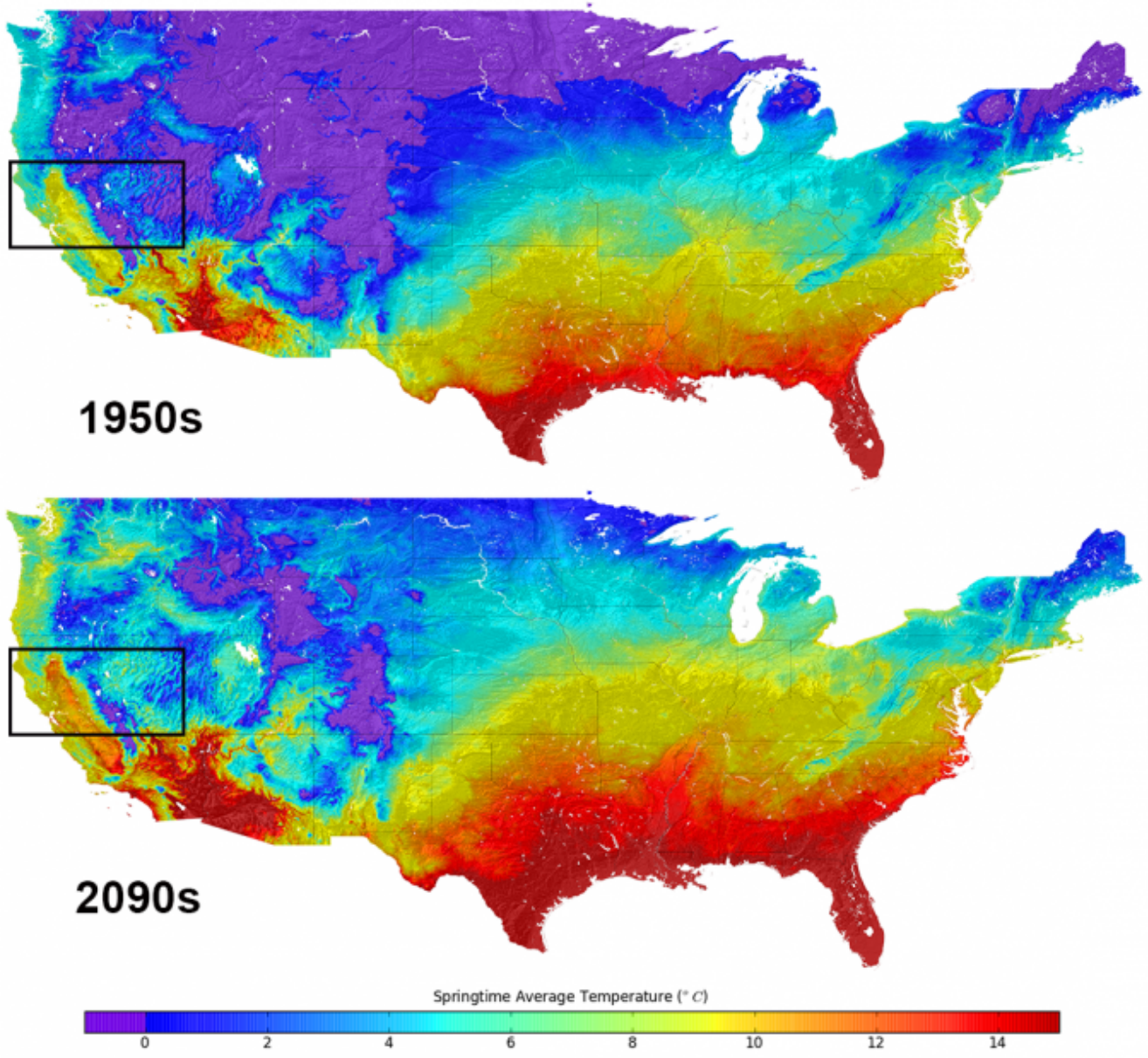
- NEX Global Daily Downscaled Projections (GDDP)

- Using 35 CMIP6 models
- 9 variables

- 25 km globally

- Used for local/regional impacts, including extremes

- Cloud access



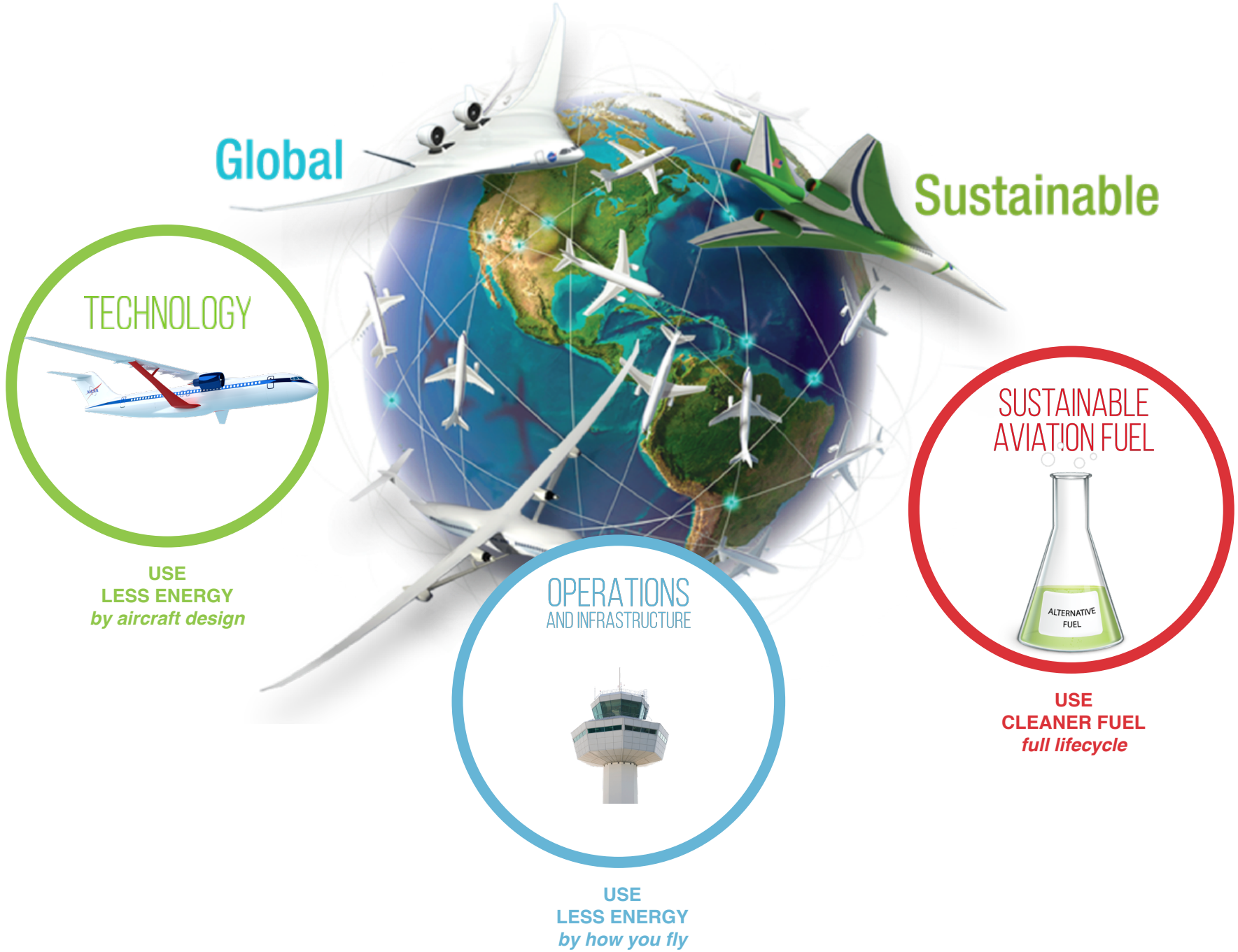
Daily variables:
- Humidity
- Temperature
- Rainfall
- Winds
- Surface radiation

Experiments:
- Historical
- SSP2-45
- SSP5-85

Pillar 3: Technology

Sustainable Aviation

- Airspace Operations research to reduce fuel use
- More efficient engines
- New designs for net-zero flying
  - hydrogen fuel cells
  - turbo-electric powertrains
- X-57 All-electric flight demonstrator - first tests in FY21, flight demonstration in FY22.

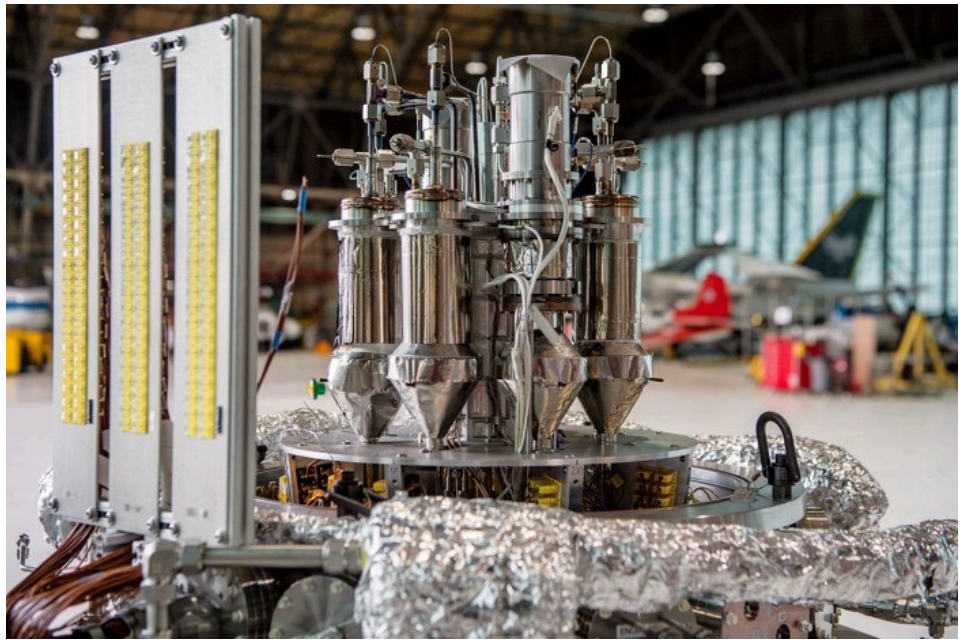


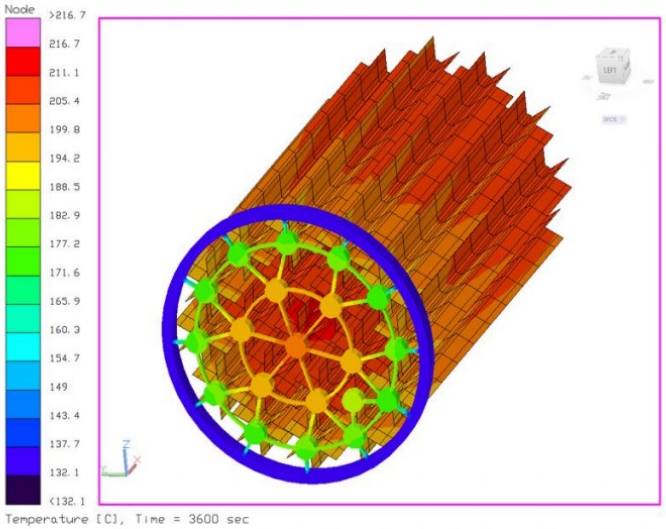
Space Technology

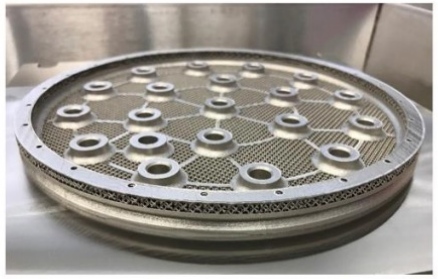
- Spinoffs for clean energy, software, apps, environmental monitoring, carbon dioxide removal, small nuclear

- Prizes to encourage efficient aircraft (Green flight challenge, 2011, Earth and Space Air Prize 2018)

- Partnerships with foundations, other agencies







- Heater mounting plate lattice removed for clarity.
- Axial fin gradient reduced from 17°C (Titanium End Plate/ASRT-5A) to 11.5°C (outside cartridge) and 6.3°C (center cartridge) with additive manufactured Inconel end plate and 13X sorbent.

Pillar 4: Partnerships

Partners not just users

- Agencies
- Inter-agency committees
- Local Government
- Non-profits
- Business
- Community groups
- International agencies

SERVIR GLOBAL

Robert Wood Johnson Foundation

Gulf of Maine Research Institute

NASA esa JAXA

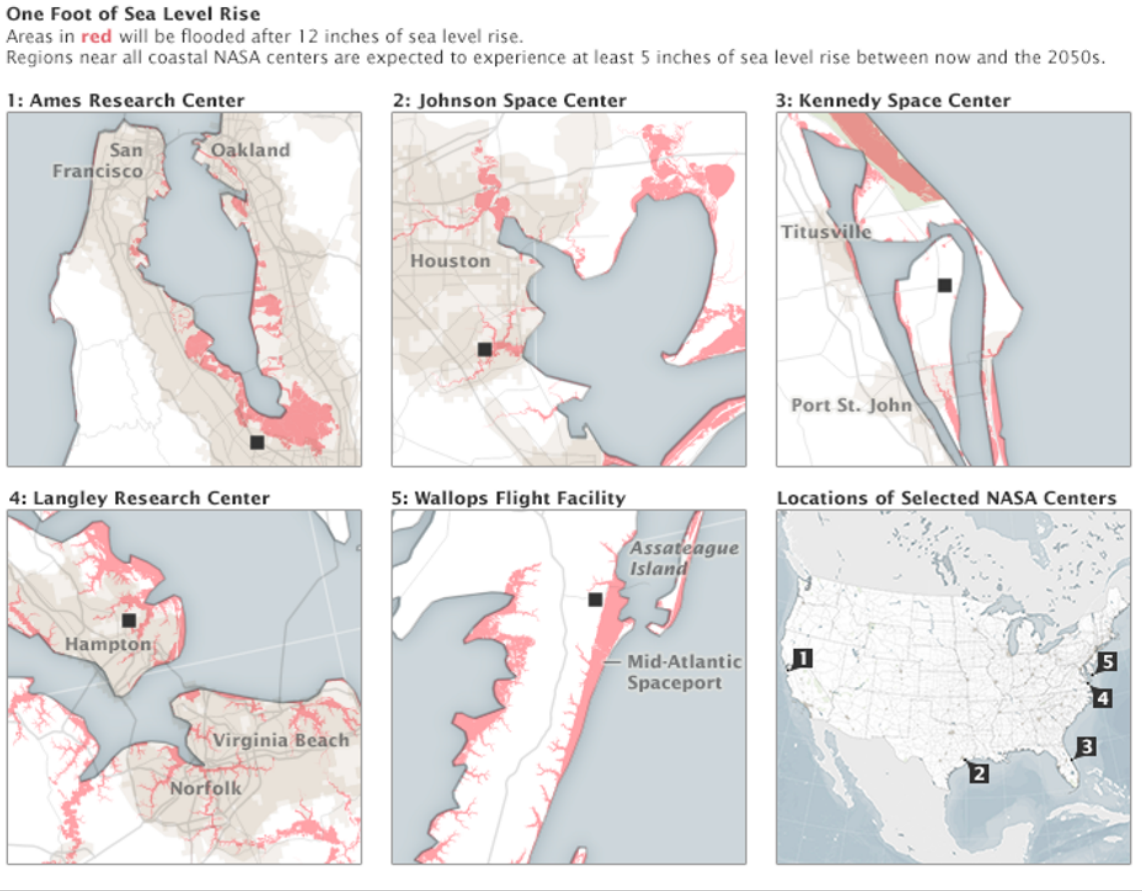
C40 CITIES

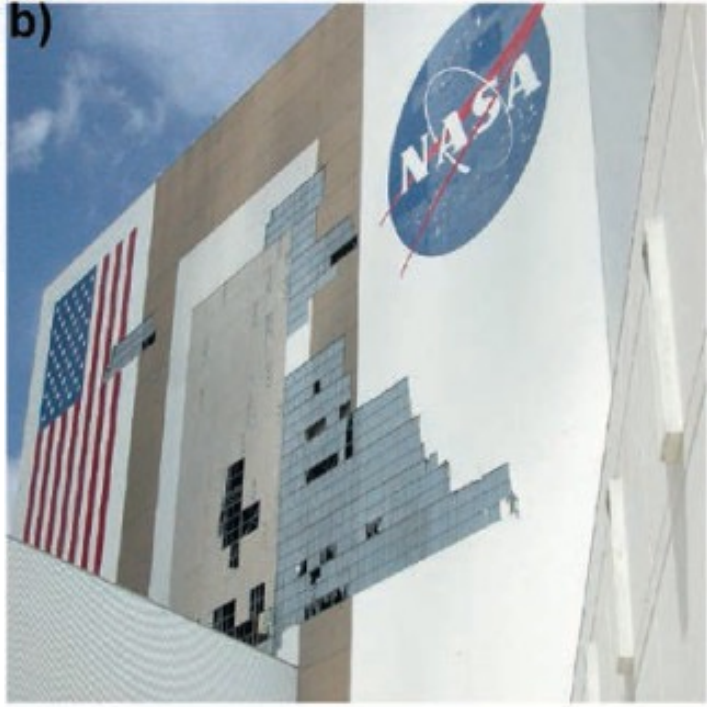
POWER
Prediction Of Worldwide Energy Resources

Pillar 5: Resilience

Center Vulnerabilities

- Sea level rises
- Wildfires
- Severe storms





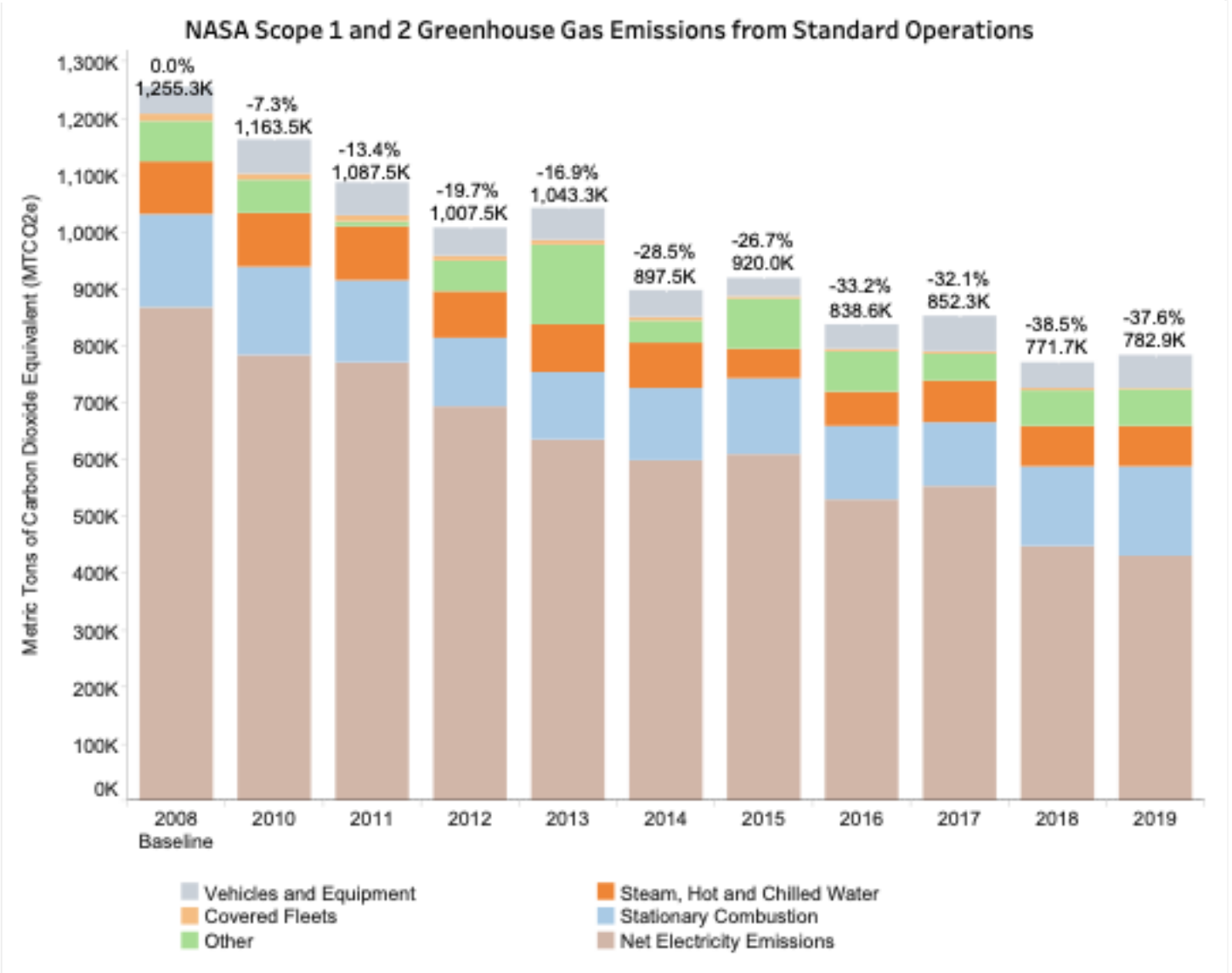
Pillar 6: Footprint

NASA’s Institutional Footprint

- Scope 1 and Scope 2 emissions since 2008
- Facilities, energy use, on-site vehicles
- Doesn’t include launches
- No commuting

- Decrease of ~38% since 2008.
- Mostly due to building + efficiency upgrades

NASA@WORK

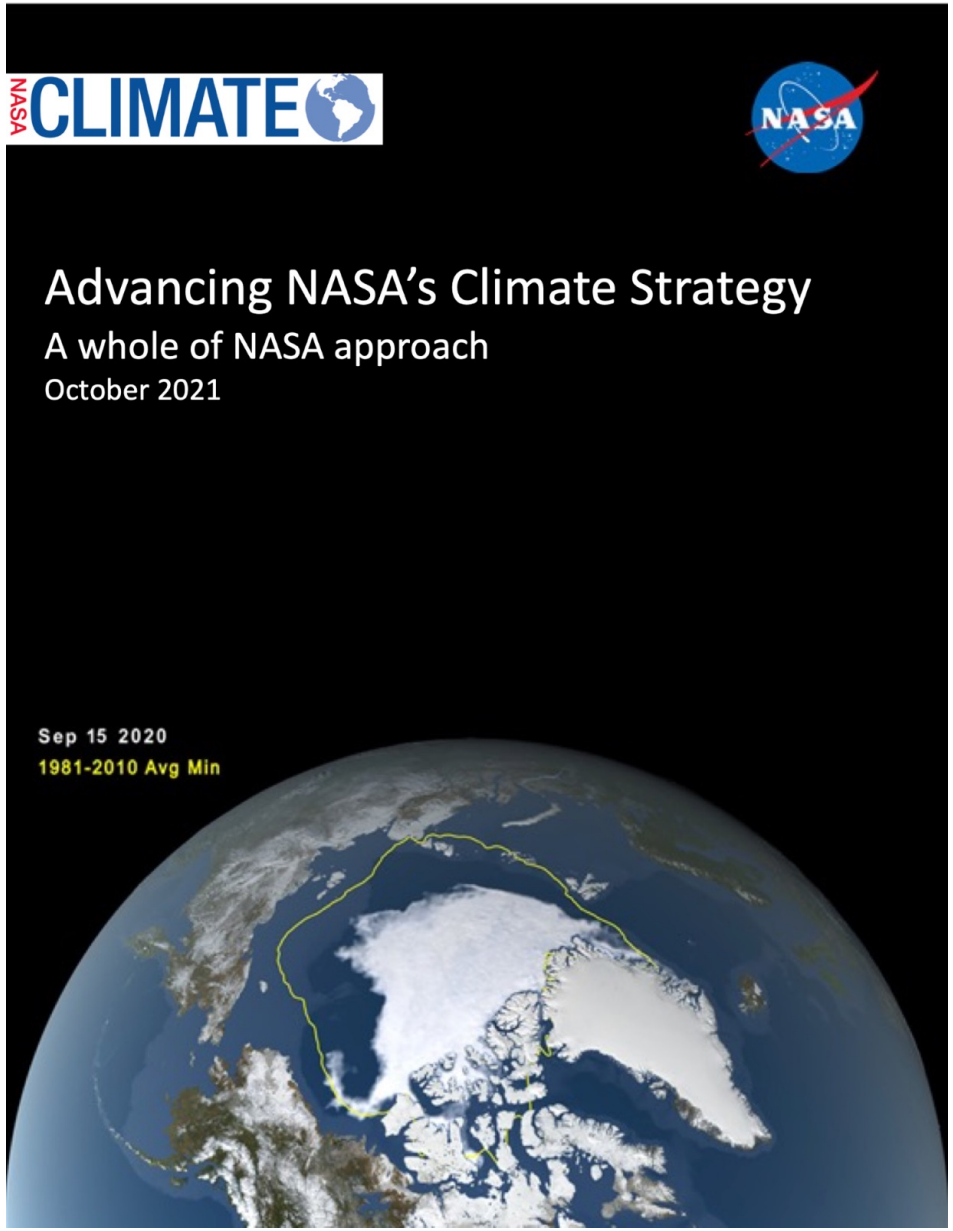


Recommendations and New Initiatives

- NASA's *Climate Action Plan* delivered to CEQ in August
- Priorities:
  - Ensure Access to Space
  - Integrate Climate Adaptation into Agency and Center Master Plans
  - Integrate Climate Risks into Agency Risk Analysis and Resilience Planning
  - Update Climate Modeling to Enable Better Understanding of Agency Threats and Vulnerabilities
  - Advance Aeronautics Research on Technologies and Processes that Reduce Contributors to Climate Change
- Special Focus Areas:
  - Update Climate Vulnerability Assessments
  - Enhance Climate Literacy in its Management Workforce
  - Agency Actions to Enhance Climate Resilience

Advancing NASA's Climate Strategy

- What is NASA's Climate Portfolio?
- Strengths
- Areas where improvements can be made
- New opportunities
- Linking climate to other Agency priorities



Will have 7 sets of recommendations:

- Integration of climate across directorates/divisions
- Enhance NASA role in climate-related decision support
- Engage more effectively w/interagency partners and stakeholders
- Increase data accessibility
- Further embed resiliency and sustainability into NASA decisions
- Increase coordination on technology development
- More coherent and deeper efforts on climate communications

- A NASA *Center for Climate Resilience?*
  - Help coordinate agency efforts
  - New Applied Sciences focus area on Climate-related Decision Support (FY22 budget pending)
  - Extend from NASA Center Resilience to support for USGCRP, NOAA, FEMA, FGDC efforts
  - Education and training on NASA resources
    - Sea level projections (via IPCC AR6)
    - NEX GDDP
    - Integration with socio-economic data (SEDAC)
  - Open Science initiatives for better equity and data integration

Thank you!