Value of Earth Observations—
Multiple Users
Multiple Value Metrics
Multiple Requirements

Betsy Weatherhead
U. Colorado (retired)

June 15, 2026

NATIONAL ACADEMY OF SCIENCES

Progress Toward Implementing the Decadal Survey "Thriving on Our Changing Planet: Engaging A Broader Constituency"

Recommendation: Prior to the next decadal review, NASA, the National Oceanic and Atmospheric Administration, and the U.S. Geological Survey should engage a broader Earth sciences constituency by

- *• Identifying Earth observation stakeholders, improving understanding of their short- and l ong-term needs, and encouraging participation of the community of stakeholders in the next decadal*

  survey. These stakeholder groups should include both the scientific community and communities impacted by climate change, including historically marginalized and underrepresented groups that are often disproportionately impacted.

- *• Sponsoring workshops to engage the entire Earth system community to better address observational needs for interdisciplinary and crosscutting issues. The workshops should*

  1. *o Gather input on priorities,*
  2. *o Communicate expected program resource constraints to help set expectations,*
  3. *o Sensitize participants to the need for working within a holistic Earth system science rather than disciplinary framework when considering implementation options,*
  4. *o Support development of brief reports outlining community progress and expressing observationneeds at discipline and crosscutting topic area levels (e.g., sea level, modeling), and*
  5. *o Ensure systematic representation of interdisciplinary*

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Outline

- Value of Observations
- Types of observations
- National / International Activities
- Looking forward

Whose purpose?

VALUABLES

- Six year effort to identify economic value of Earth Observations led by Yusuke Kuwayama

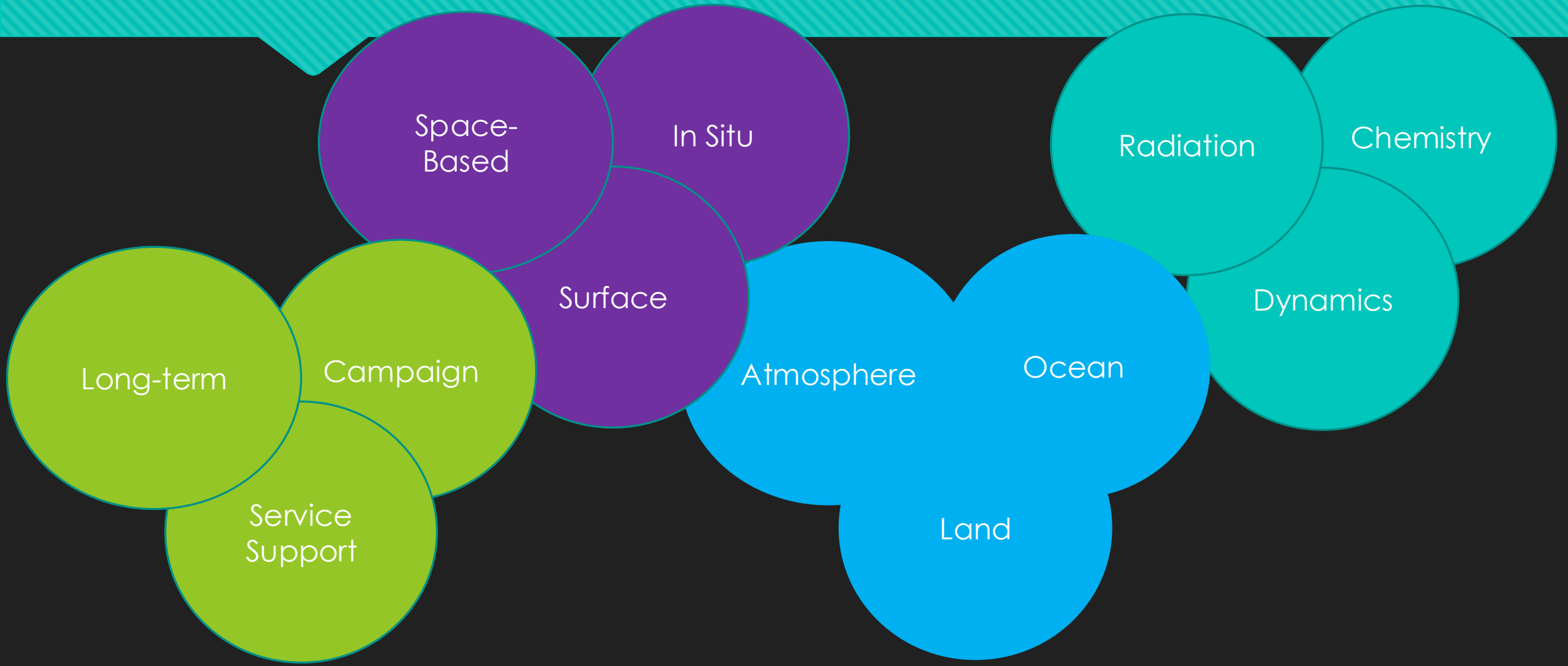
Figure 2. VALUABLES Impact Assessment Framework: Satellite Data on Harmful Algal Blooms vs Site Testing and User Reports Only

✓ Reference Case	✗ Counterfactual Case
INFORMATION	
Satellite data on HABs In-situ testing by environmental managers User reports of algal blooms	In-situ testing by environmental managers User reports of algal blooms
DECISIONMAKER ACTIONS	
Warnings and public advisories Water access closures Actions considered **weekly** or as reported Advisories posted **7 days earlier** than in the counterfactual case	Warnings and public advisories Water access closures Actions considered **monthly** or as reported Advisories posted **7 days later** than in the reference case
OUTCOMES FOR PEOPLE AND THE ENVIRONMENT	
0 people exposed to cyanoHAB **0 people experience symptoms** **$0 in costs** due to health outcomes	**8,000 people exposed** to cyanoHAB **400 people experience symptoms** **$370,000 in costs** due to health outcomes

How Much Is Satellite Information about Soil Moisture Worth to Society?

What's the value of having more accurate information about how much water is in the soil where farmers grow crops? This VALUABLES impact assessment developed a framework to estimate the value of using information from the Soil Moisture Active Passive satellite mission to reduce uncertainty about soil moisture, a key factor for developing accurate predictions about crop yields. The researchers quantified the value of the satellite data by looking at the value of reducing uncertainty about crop yields in corn and soybean futures markets. Examining prices in futures markets helps reveal people's perception of uncertainty and indicates how much people are willing to

Types of Earth Observations



NASA's Atmospheric Investigator's Meeting, Langley, 2026

- **Clouds/Aerosols:** led by Meloë Kacenelenbogen, Matt Lebsock, Kerry Meyer, Atmospheric
- **Dynamics/Thermodynamics:** led by Amin Nehrir Derek Posselt, Patrick Duran
- **Tropospheric Composition:** led by Glenn Wolfe, Katie Travis Matt Johnson
- **Stratospheric Composition:** led by Qing Liang, Rei Ueyama, Pam Wales
- **GHG Implications for the Atmosphere:** led by Sean Crowell, Junjie Liu, Josh Laughner
- **Radiative Balance of the Earth System:** led led by Patrick Taylor, Yolanda Shea, Maria Hakuba

NASA's Atmospheric Investigator's Meeting, Langley, 2026

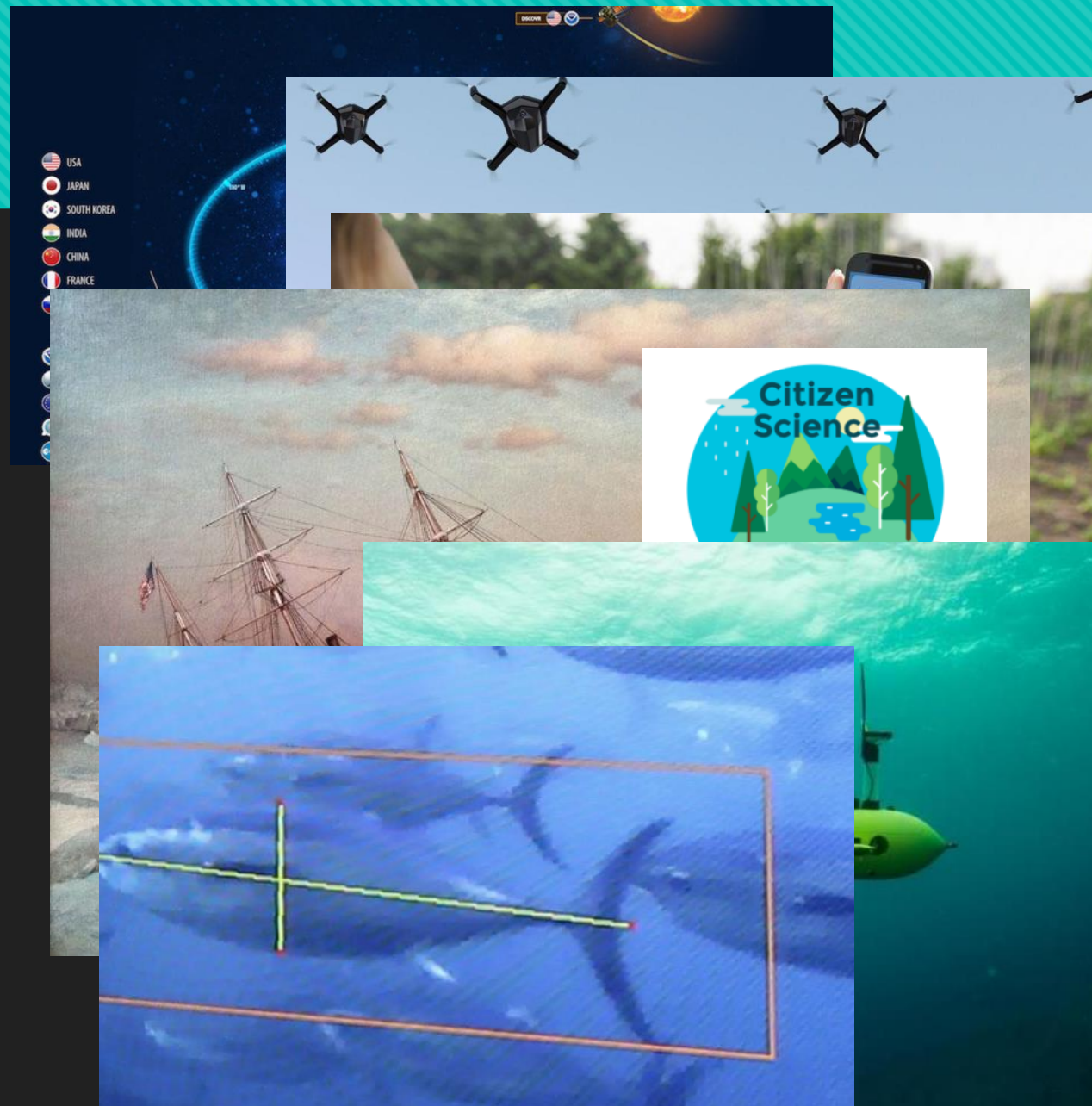
We are in a renaissance of Earth observations

- Constellations of satellites
- Unmanned aircraft - big, small and in swarms
- Cell phones taking pressure observations
- Citizen scientists making irreplaceable contributions
- Autonomous underwater vehicles
- Video and Artificial Intelligence “counting” fish

- More deployable than ever before.

- Innovation from: government laboratories, universities and private sector—big and small.

- More ideas than resources for development



How do we design and value and value a climate observing system?

- Identify major science questions and important societal needs.
- One possibility is to use WCRP Grand Challenges.
- Types of Earth observationspan a number of spatial and temporal ranges
  - Long-term changes
  - Understanding processes
  - Earth services

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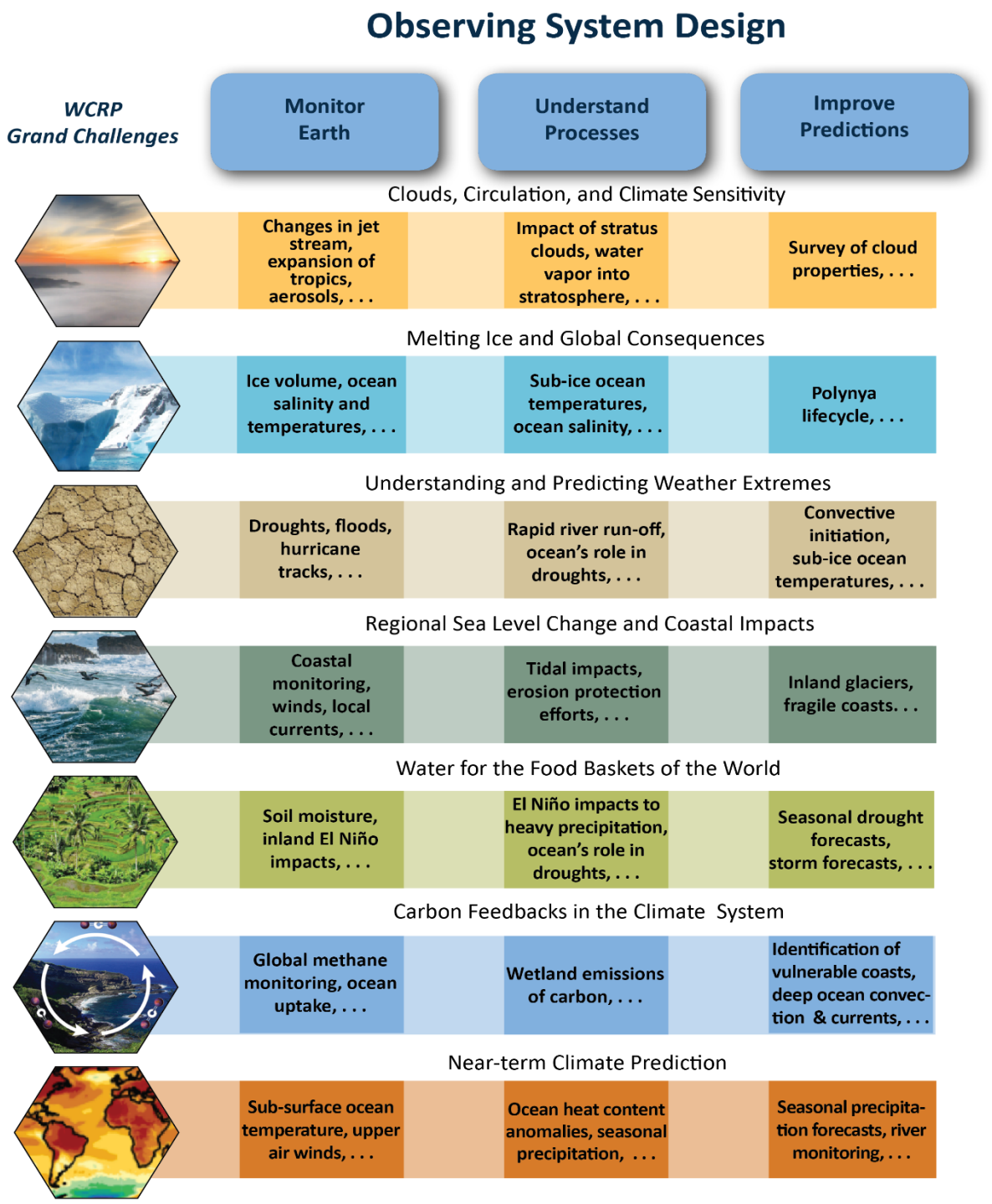
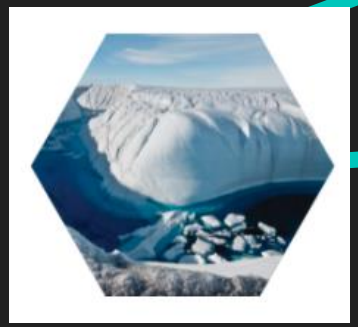


Proposed Priorities -- observing system agnostic

- **Guy Brasseur:**

  Mechanisms for underwater ice melt.



Future Climate Observing System Design

WCRP Grand Challenges	Monitor Earth	Understand Processes	Improve Predictions
Clouds, Circulation, and Climate Sensitivity	Changes in jet stream, expansion of tropics, aerosols, . . .	Impact of stratus clouds, water vapor into stratosphere, . . .	Survey of cloud properties, . . .
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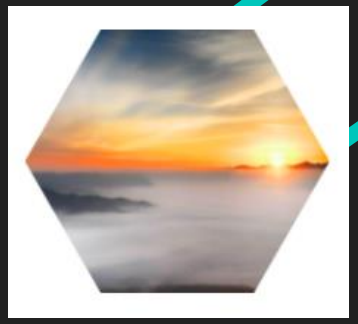
Proposed Priorities -- surface energy balance and the role of the ocean

- **Aaron Donohue:**

  Constraining surface energy balance



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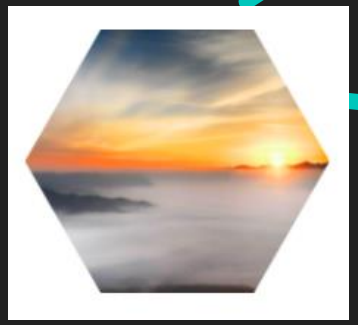
Proposed Priorities -- observing system agnostic

- **Bjorn Stevens:**

  Lower tropospheric water vapor changes and how they affect regional and global climate



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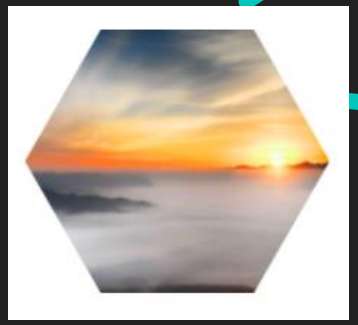

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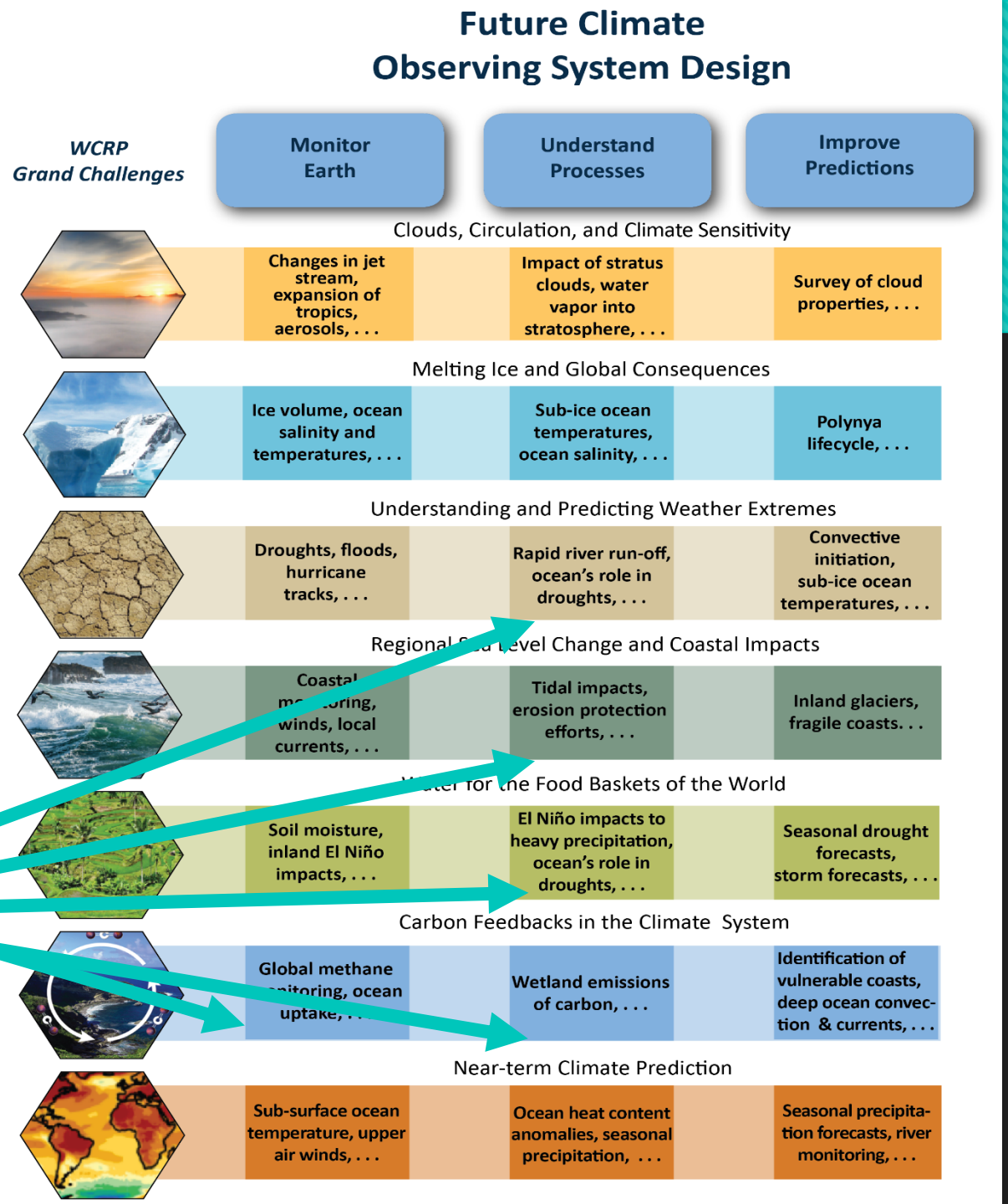
- **Ralph Keeling:**

  Impact of rising carbon dioxide on living systems and impact of living systems on carbon dioxide.



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Carol Anne Clayson, WHOI:

How are the Atmosphere-Ocean boundary layers coupled at relevant timescales in both the horizontal and vertical directions?

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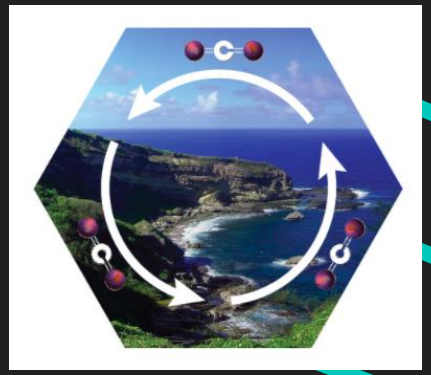
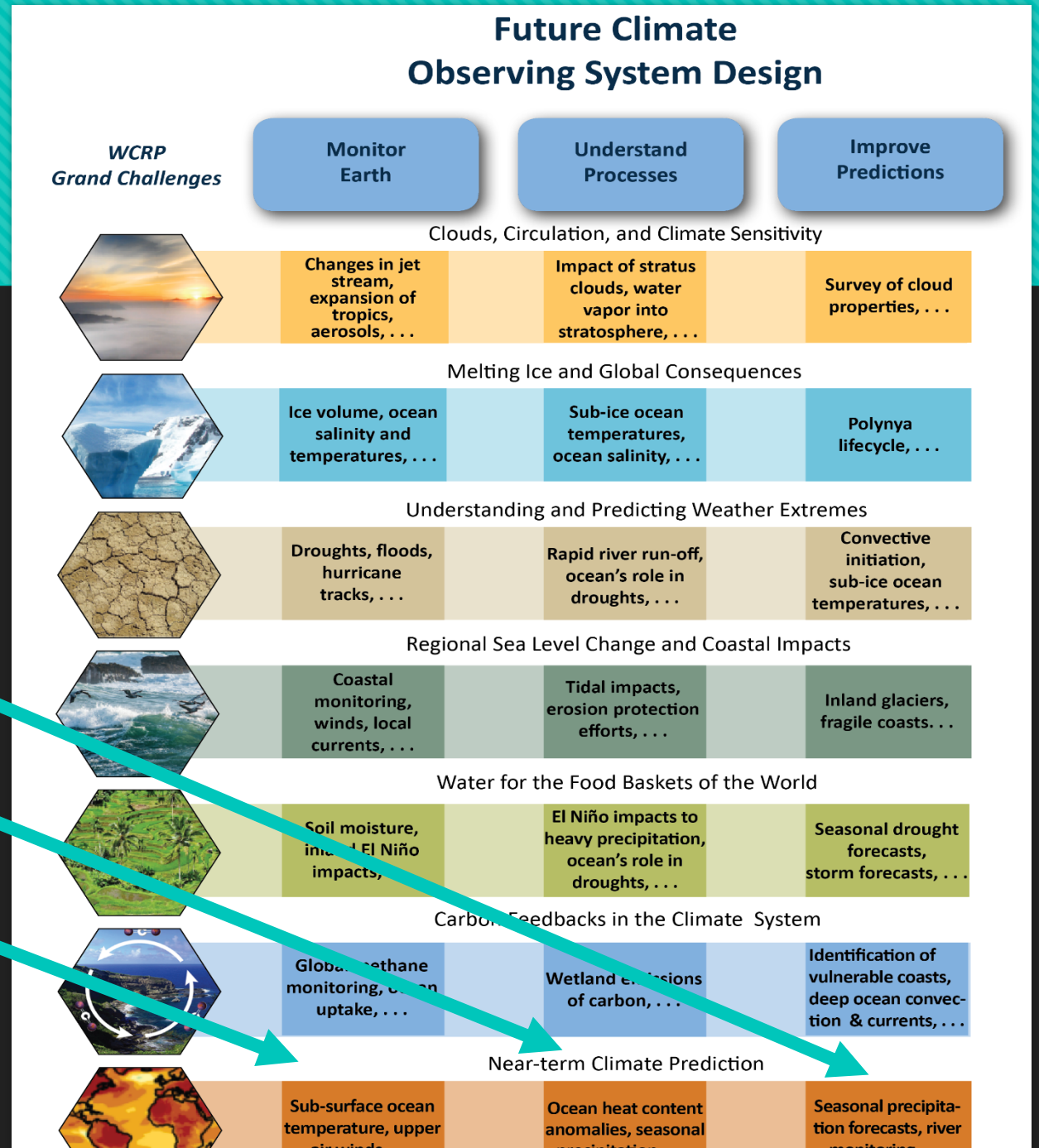
- **Matt Long, NCAR:**

  What explains variations in atmospheric CO2 on interannual to multi-decadal timescales?





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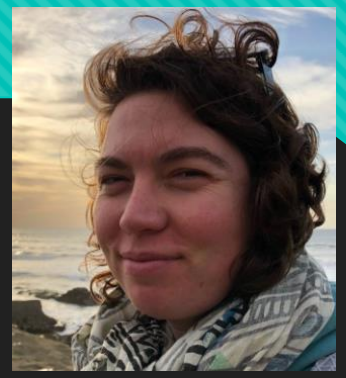
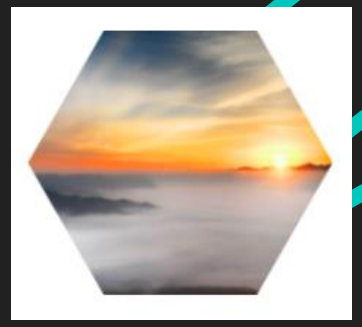


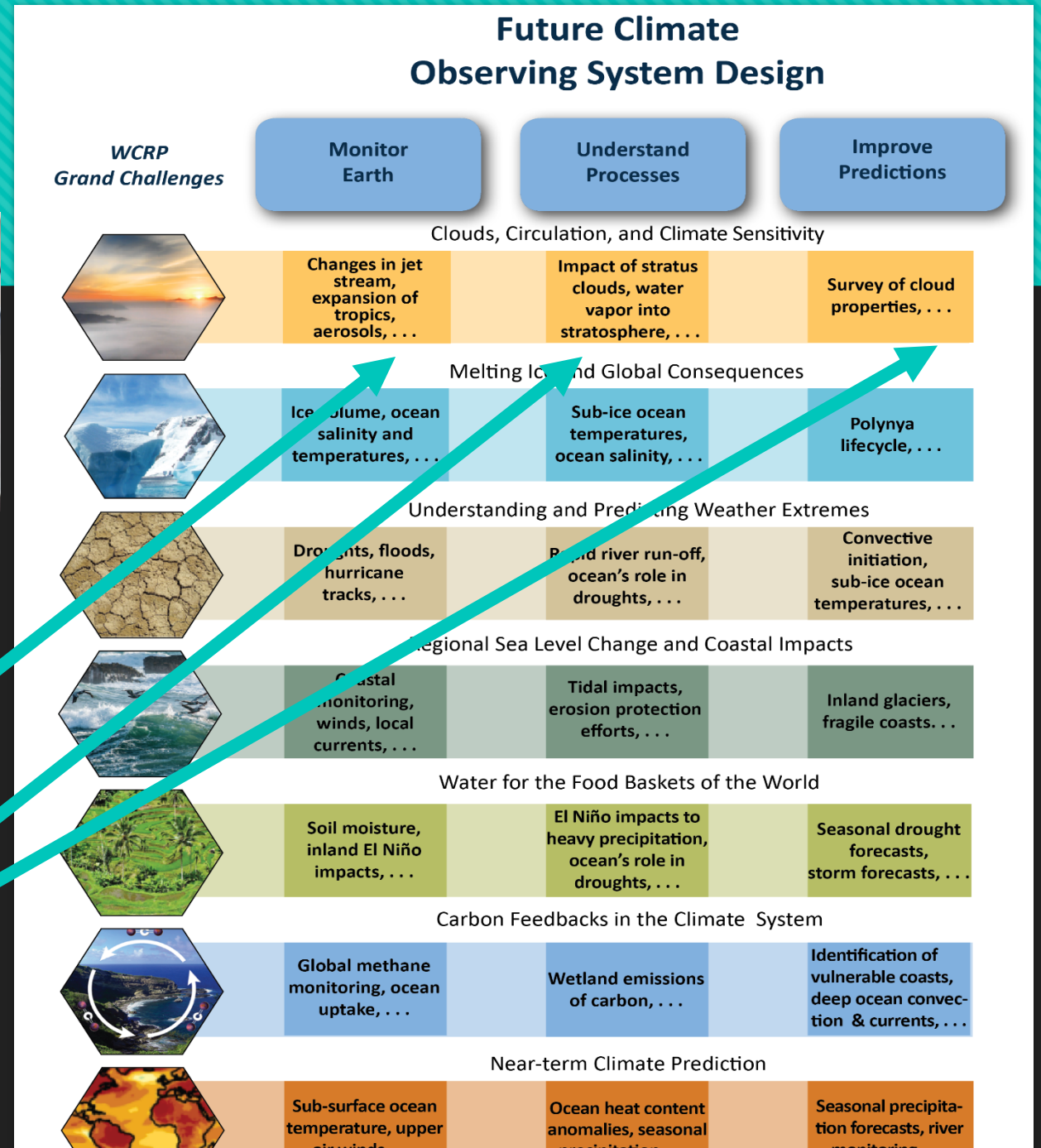
Isabel McCoy
CIRES

Geet George
MPI, Hamburg

Martin Janssens,
Wageningen U.

What are the vertically resolved winds -> divergence and convergence in the troposphere?
(paraphrased)

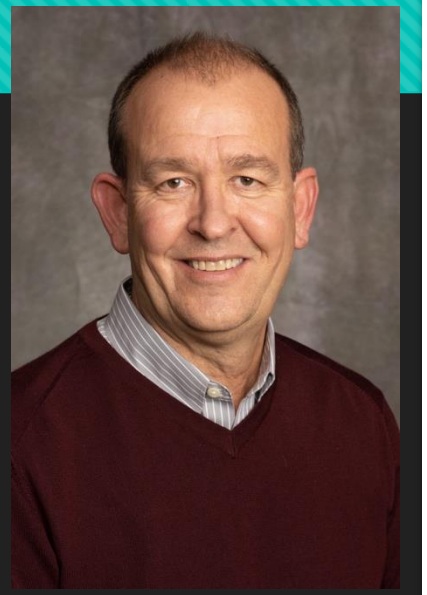




Proposed Priorities -- observing system agnostic

- **Jim Hurrell**

Be able to understand and predict the timing, duration, phase and intensity of precipitation.



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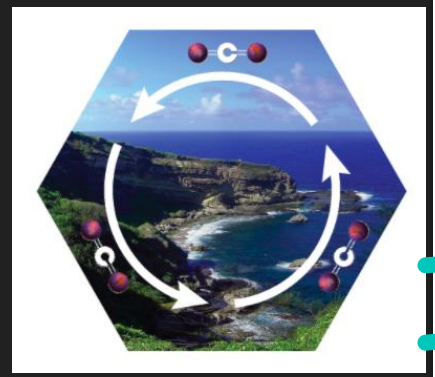
- **Joellen Russell**

  How is the lifetime of carbon changing in the ocean?



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- **Ramaswamy**

How and why is precipitation changing—including extremes?

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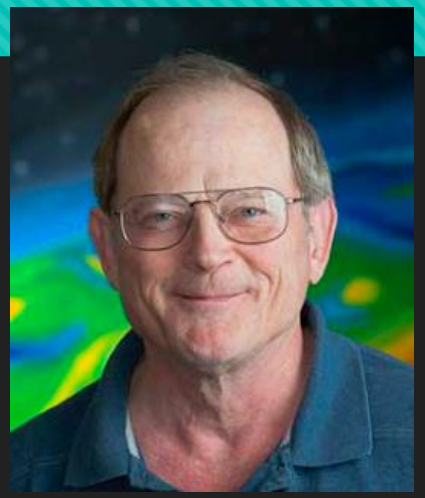
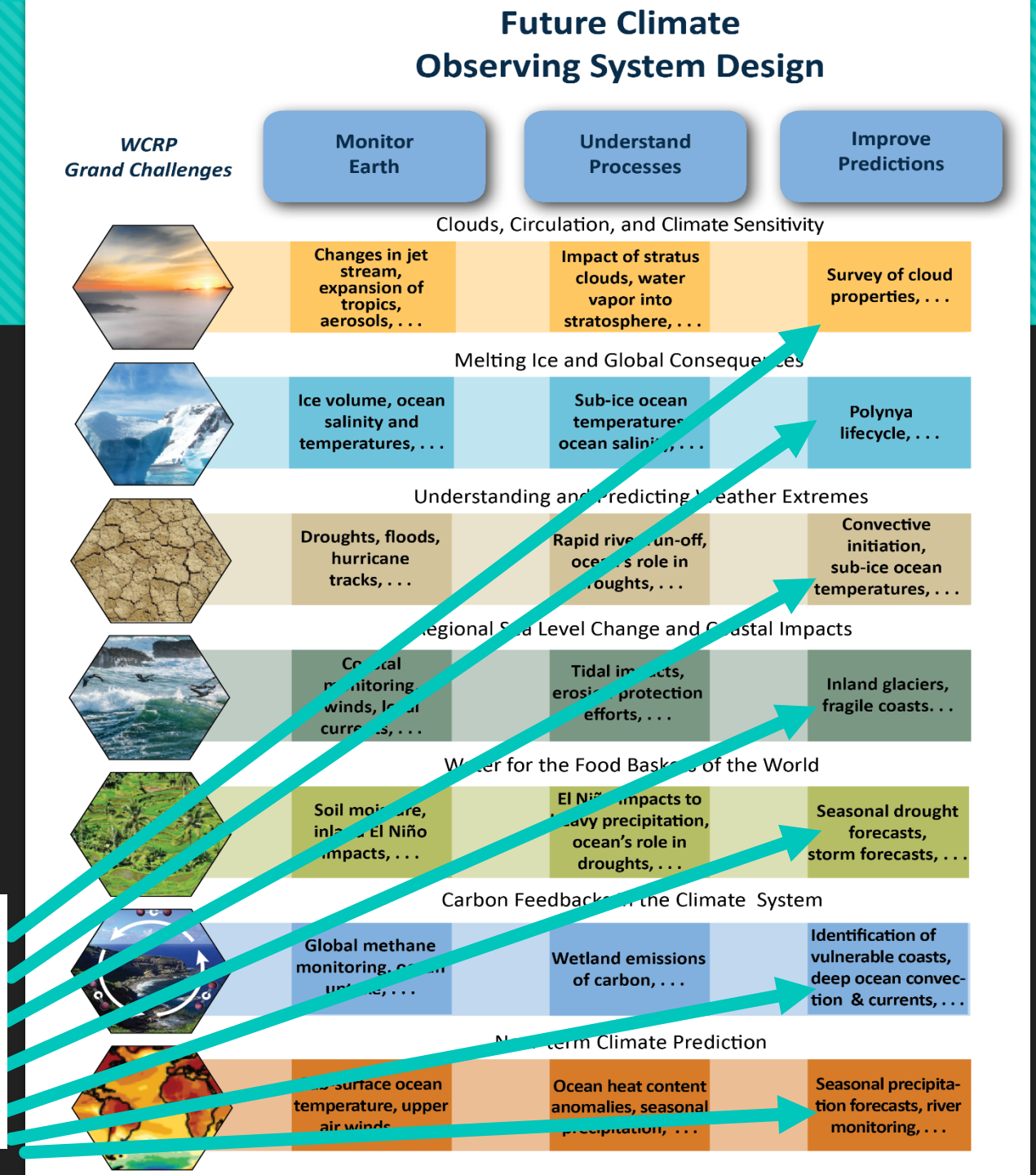
- **Bruce Wielicki**

Can we supply effective climate services?





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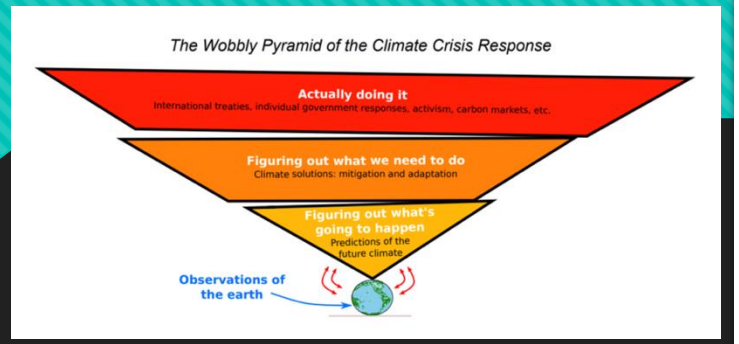
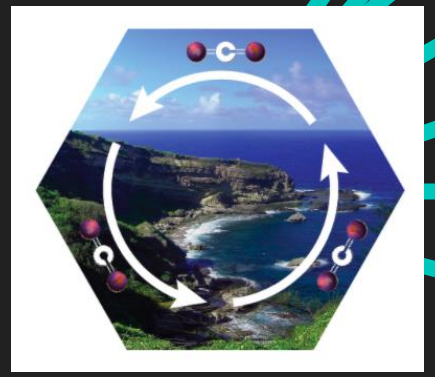
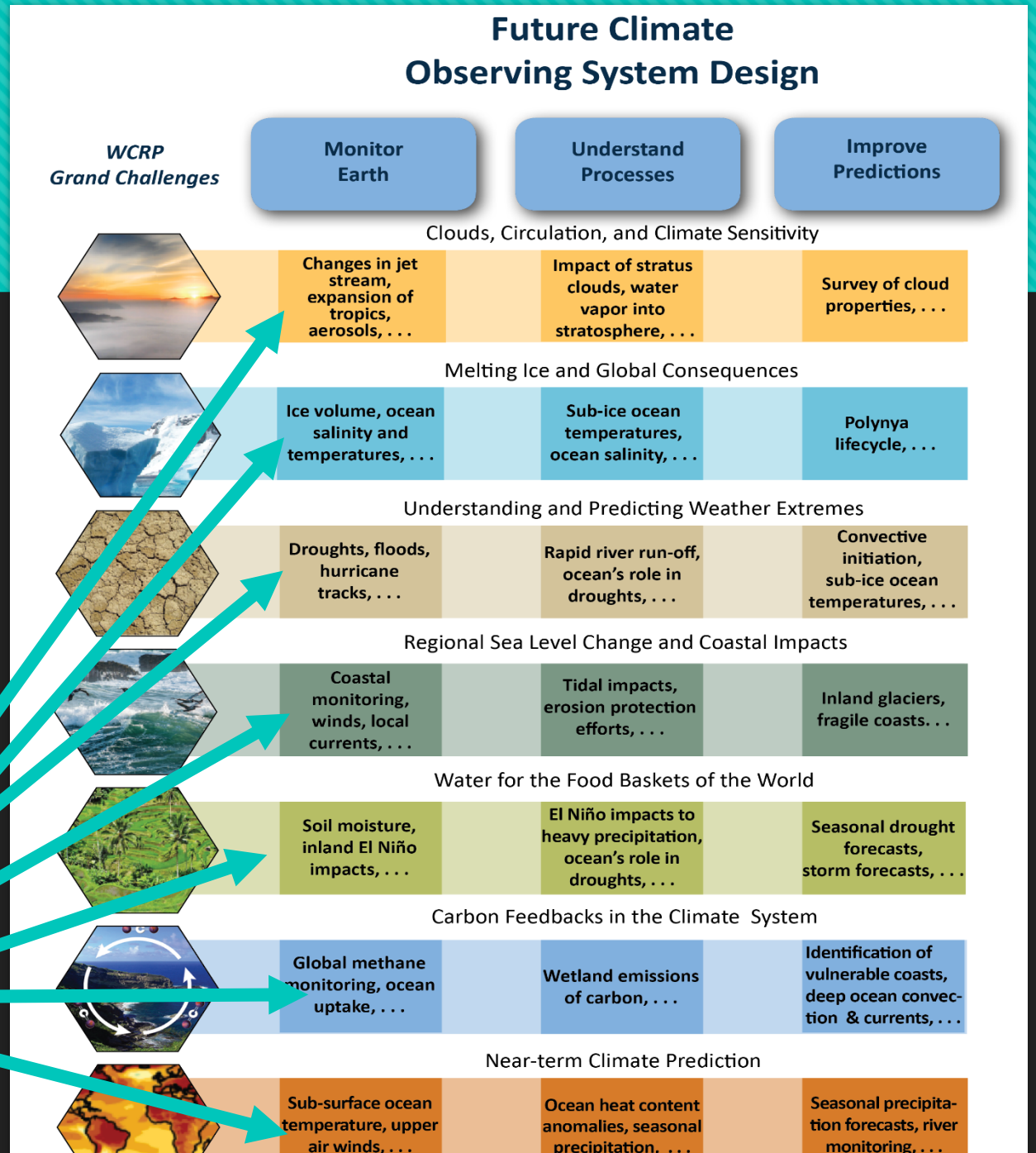


- **Keeling Curve Foundation**

Sustain Long-term Climate Observations





BIPM-Decision Grade Data

- Joint effort between WMO and BIPM
- Strong focus on carbon cycle
- 2023 convention engaged over 1000 scientists worldwide

- Complementary to FIDUCEO

Bureau International des Poids et Mesures

WORLD METEOROLOGICAL ORGANIZATION

BIPM-Decision Grade Data

Earth Observations Focus:

- Atmospheric chemistry and physics
- • Ocean and water chemistry and physics (including hydrology)
- • Earth Energy Balance
- • Biosphere monitoring
- • Cryosphere Monitoring

Carbon Focus:

- Accuracy requirements
- GHG emission estimates and the way forward to operational services
- Novel GHG concentration and flux methods and sensors
- Strengthening the linkage of remote sensing GHG concentration measurements to emission fluxes

BIPM-Decision Grade Data

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- Atmospheric chemistry and physics
  - Continuity; Tiered Networks and Low-Co Sensors; Beginning to End Measurement Requirements; Aerosols & Trace Gases; Spectroscopic Measurements
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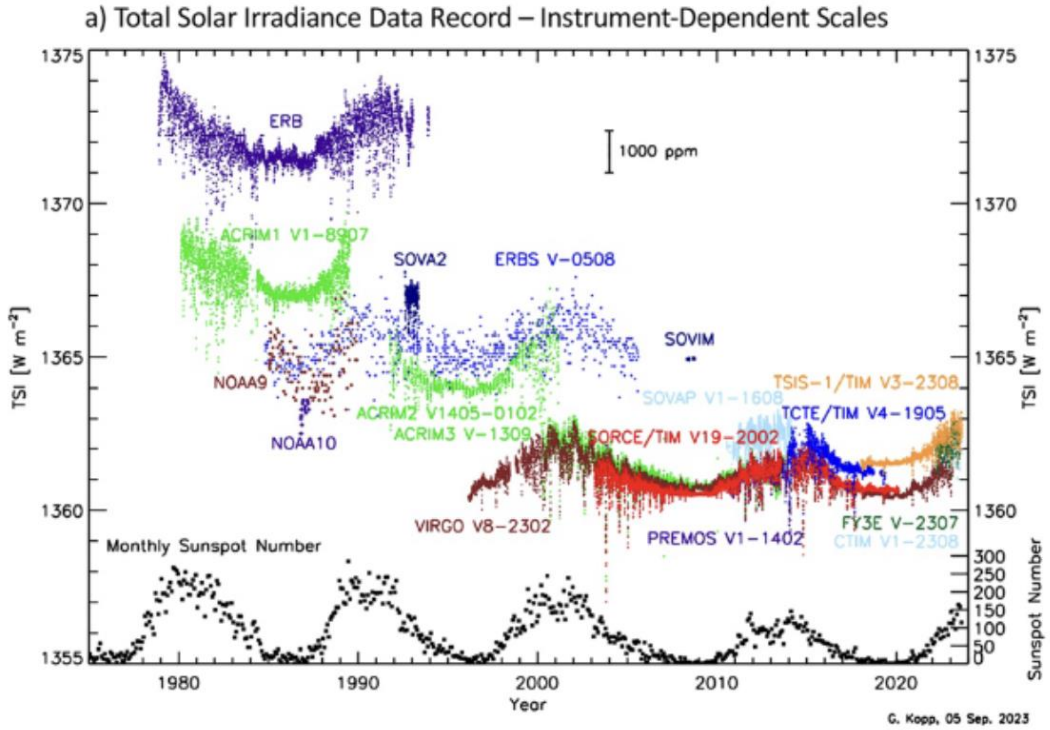
Towards a U.S. Continuity Framework for Satellite Observations for Climate
KISS Workshop Participants

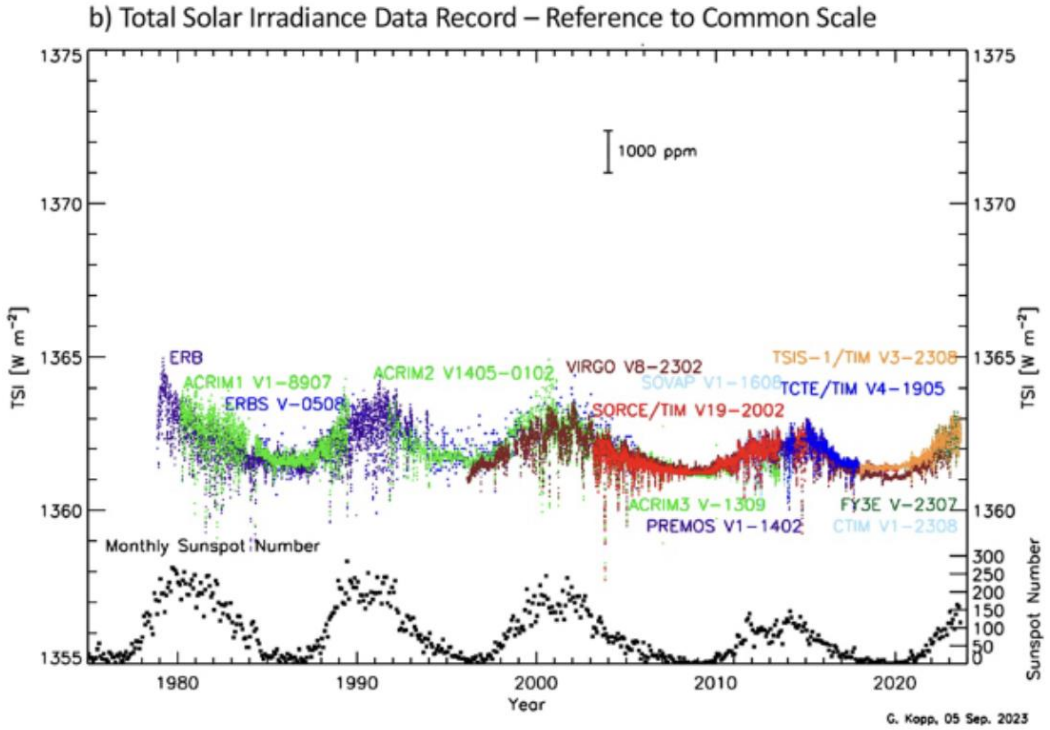
Alphabetical order by last name

Early Career Scientists were an ctive and valued part of our process.

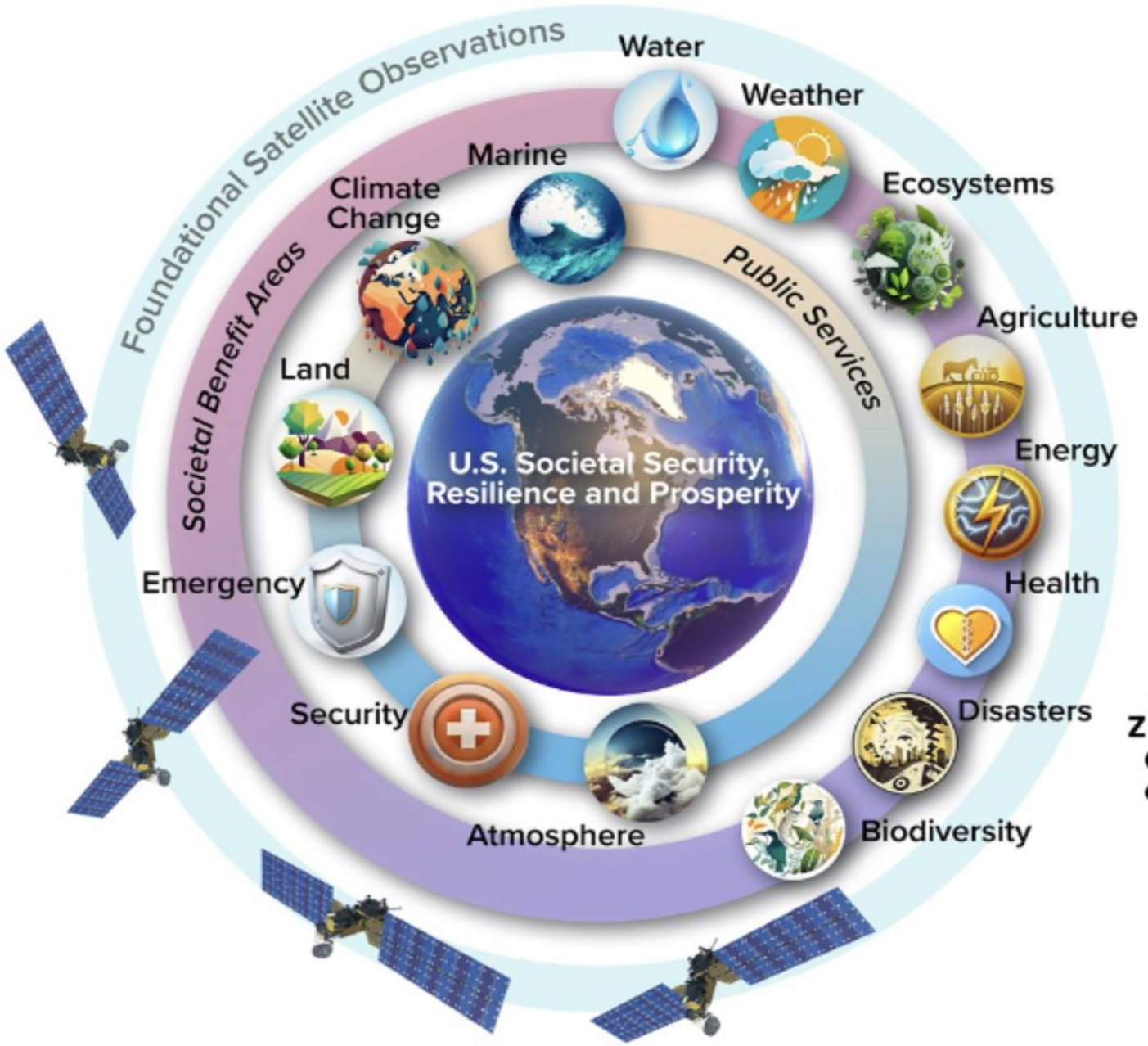
Keck INSTITUTE FOR SPACE STUDIES

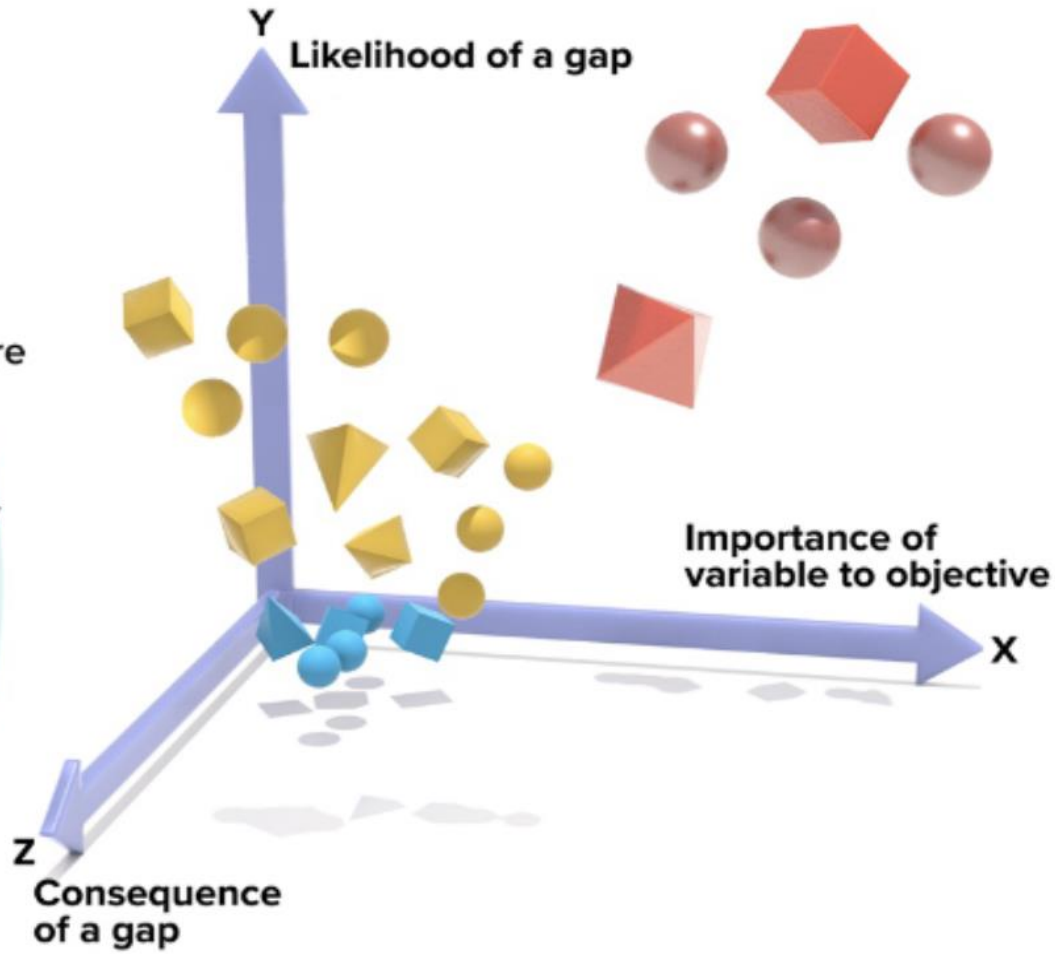
JPL-KISS-Continuity





Sustained Space-based Earth Observations: An Essential Information Infrastructure





Accounting for Multiple Factors in Establishing U.S. Priorities for Sustained Space-based Earth Observations

Climate OSSE's

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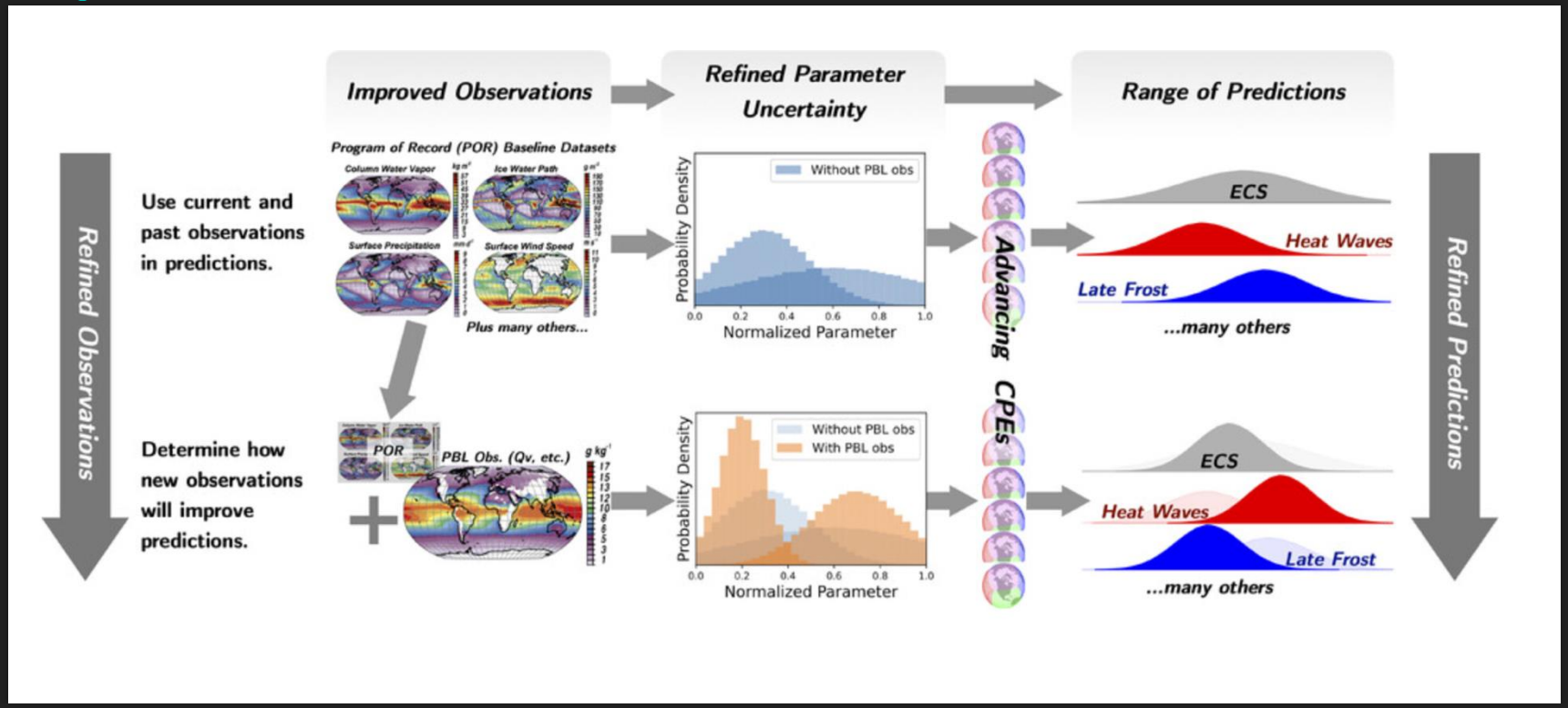
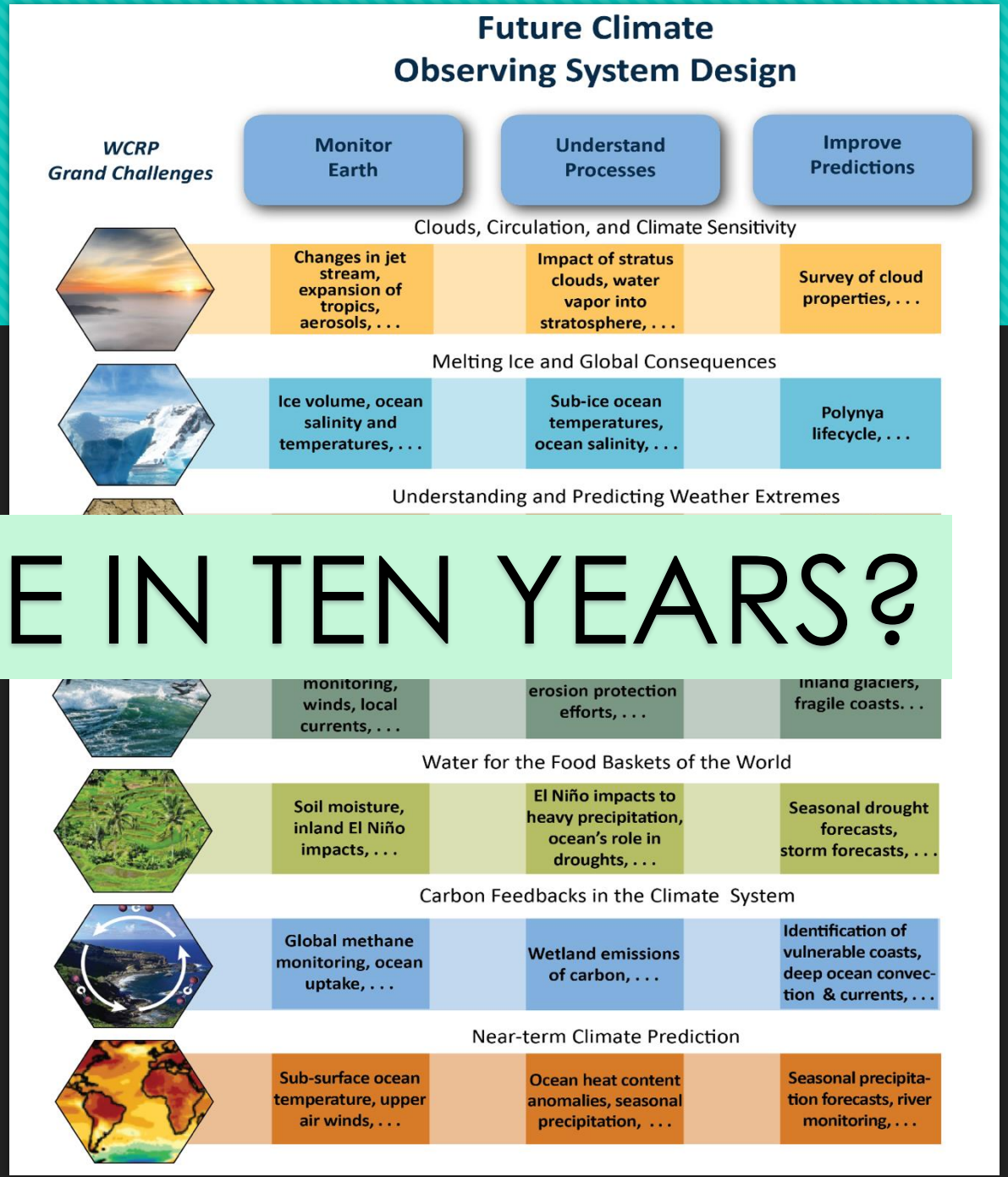
Climate OSSE's



FINAL QUESTIONS.

WHERE WILL WE BE IN TEN YEARS?

What are our highest priorities?



There have been three renaissance periods in Earth observations

- 1. World War 2, radar
  - Guided by military advantages
- 2. 1970, satellites
  - Guided by technology
- 3. Now
  - Guided by science

FINAL QUESTIONS.

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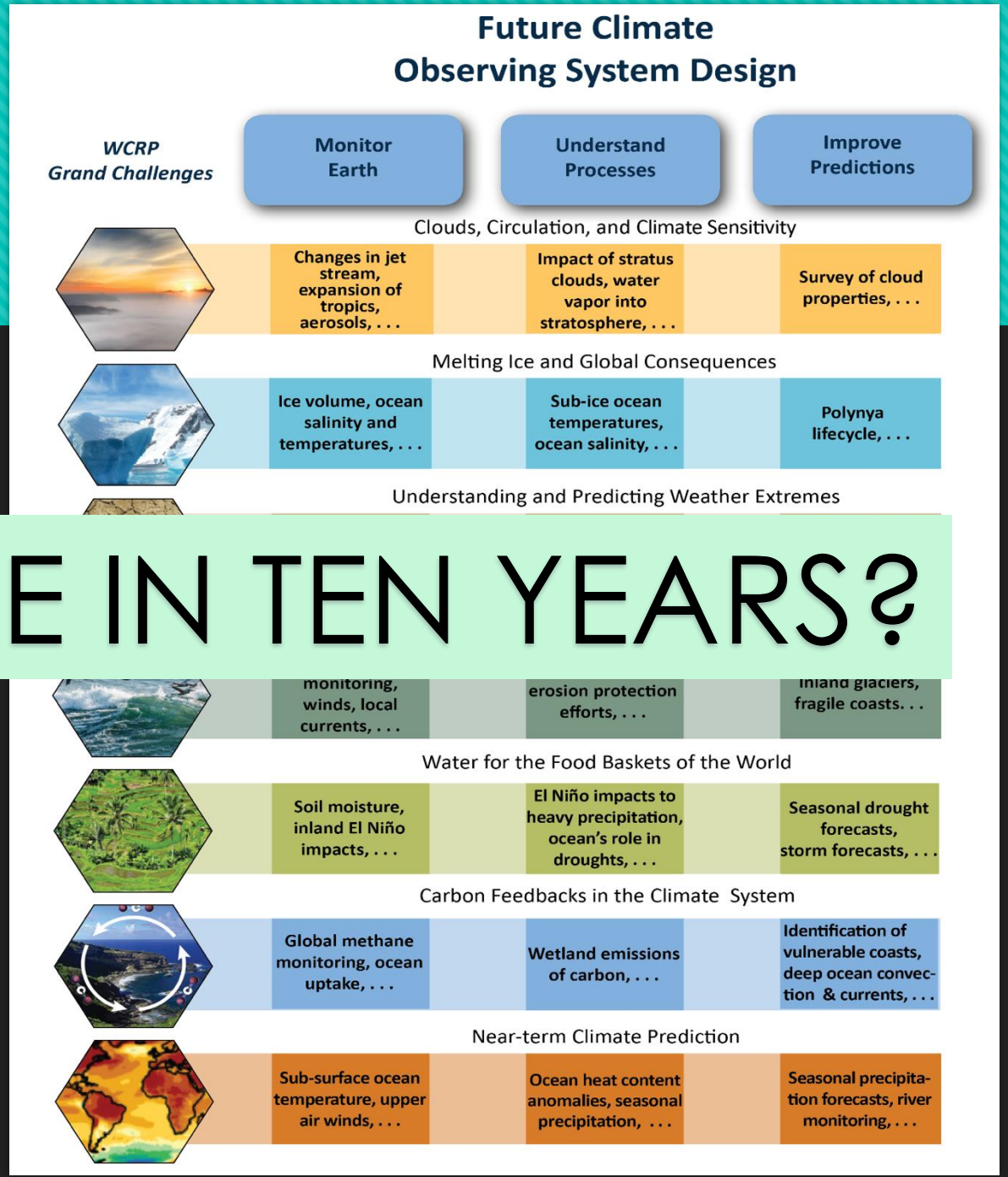


Integrity
MORALS
Principles
HONEST
Morals
ACCOUNTABILITY
HONORABLE
Rectitude
Right
VALUE
JUST
HONOR
FAIR
Ethics
Lawful
CORE VALUES
Truth
Strong
FAIR
UPRIGHTNESS
HONESTY
Truthfulness
WISE
Ethical
Philosophy
FAITH
Good Character
Moral Values
VALUES
IDEALS
LIFE
Ideology
Honest
Live
RIGHT
TRUE