SECSC Actionable Science:
Implementing a decision-oriented project portfolio

Jerry McMahon
ACCCNRS
January 22, 2014

U.S. Department of the Interior
U.S. Geological Survey

SECSC vision for science that "adds up"

- DOI Secretarial Order 3289: Producing actionable science that helps individuals and organizations understand and adapt to global change.
  - Characterize and understand the effects of climate change on fish, wildlife, and habitat
  - Provide research-based information to support landscape scale adaptive management decisions
- Today
  - Vulnerability assessment context for actionable science
  - Challenges: wicked problems
  - SECSC niche

Vulnerability Assessment

- Vulnerability = f (exposure, sensitivity, adaptive capacity)
- Vulnerability is context specific
- We measure the vulnerability:
  - **OF** a measureable characteristic of something we care about
  - **TO** a specific stressor

- Examples:
  - Vulnerability of corn prices to drought
  - Vulnerability of coastal highways to sea-level rise
  - Vulnerability of a species in the face of habitat loss

Housing prices

Cost of borrowing money

Ecosystems Goods and Services

Land Development costs

Critical Facilities & Infrastructure

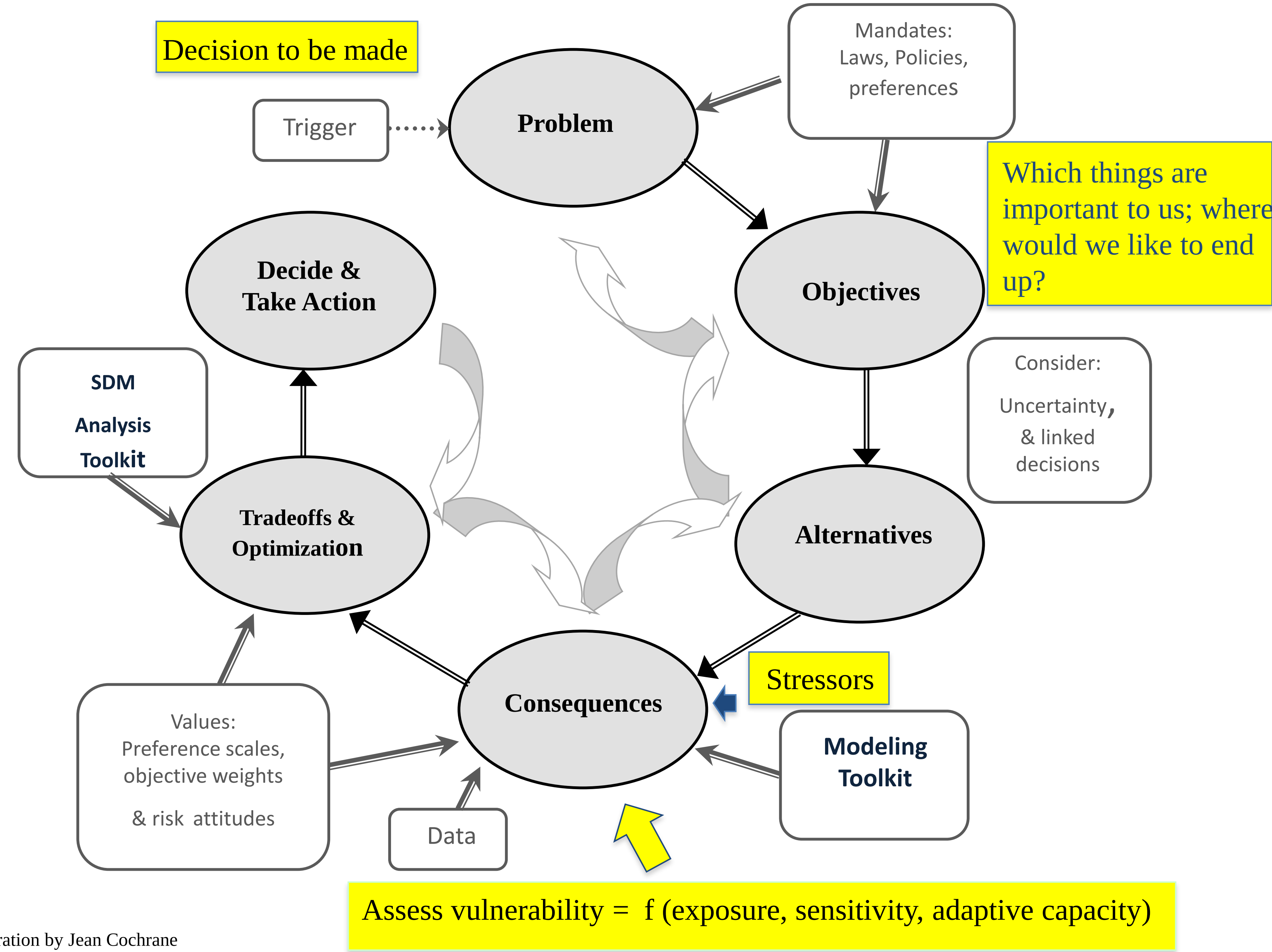


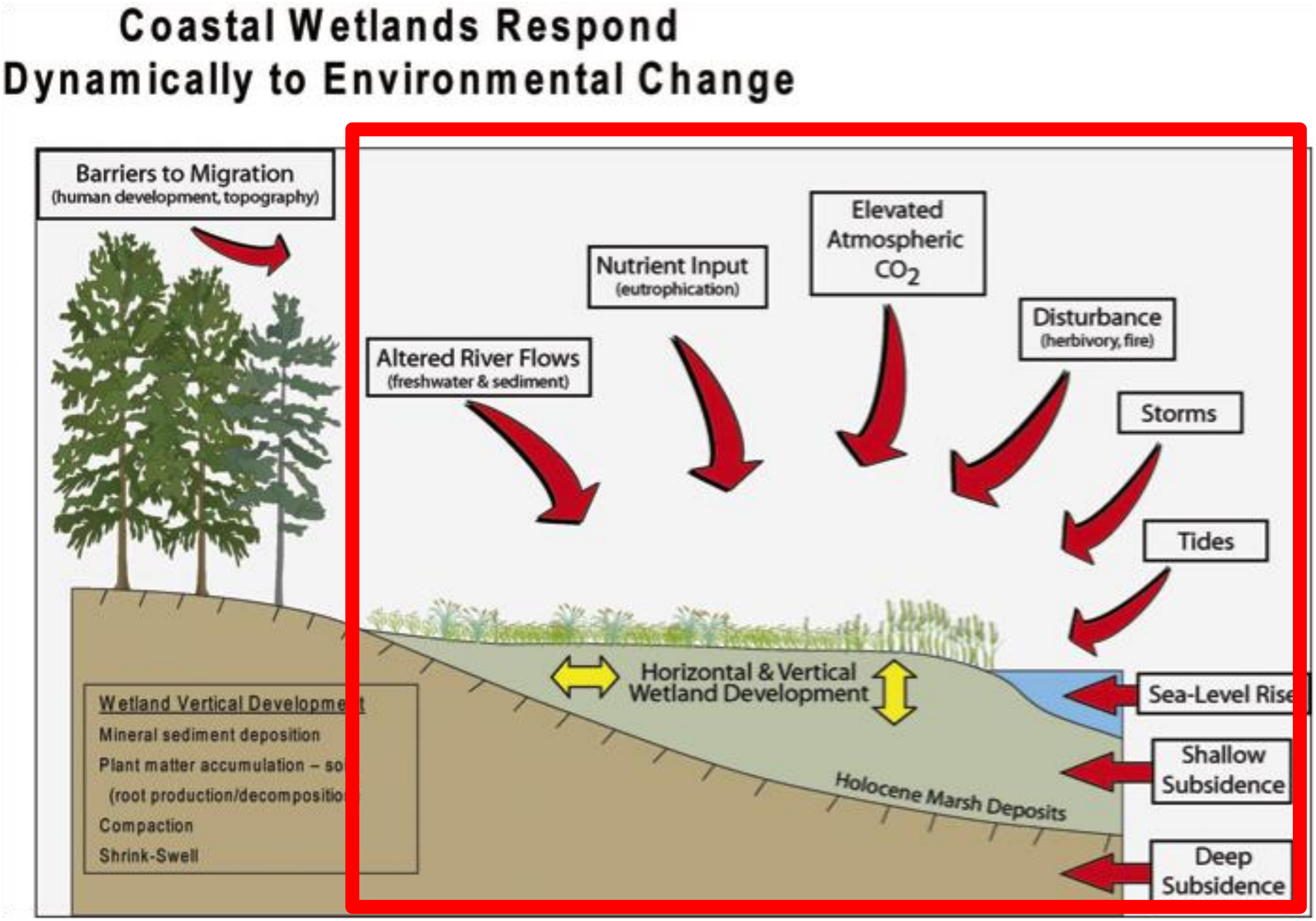
Illustration by Jean Cochrane

Actionable science challenges

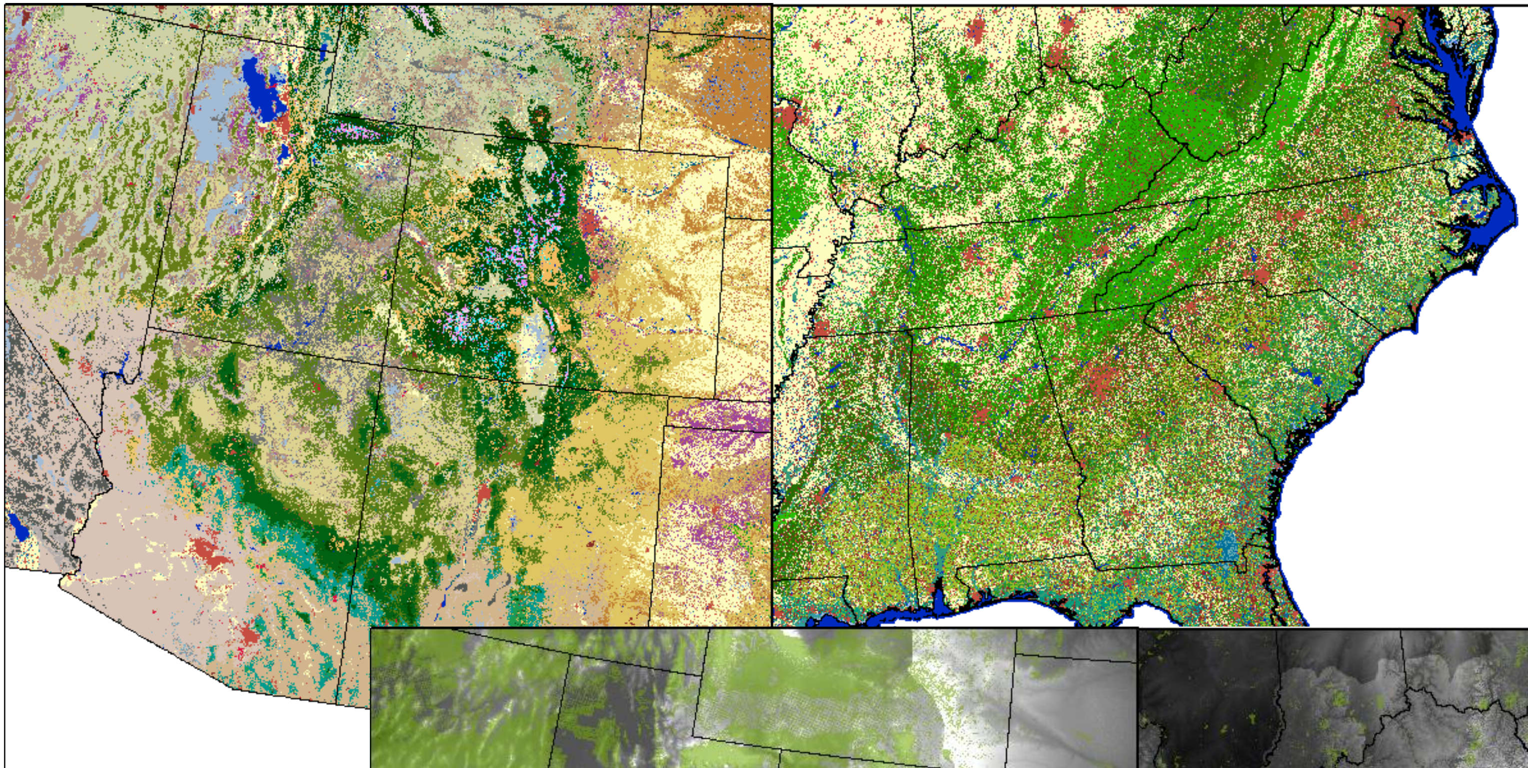
All aspects of this process for doing landscape-scale, actionable science are complicated by "wicked problems"

- Complex, coupled human-natural systems
- Heterogeneous "landscapes"
- Scale mismatch
- Adaptation response: a moving target
- Managers, scientists, and public are not experienced with handling these challenges

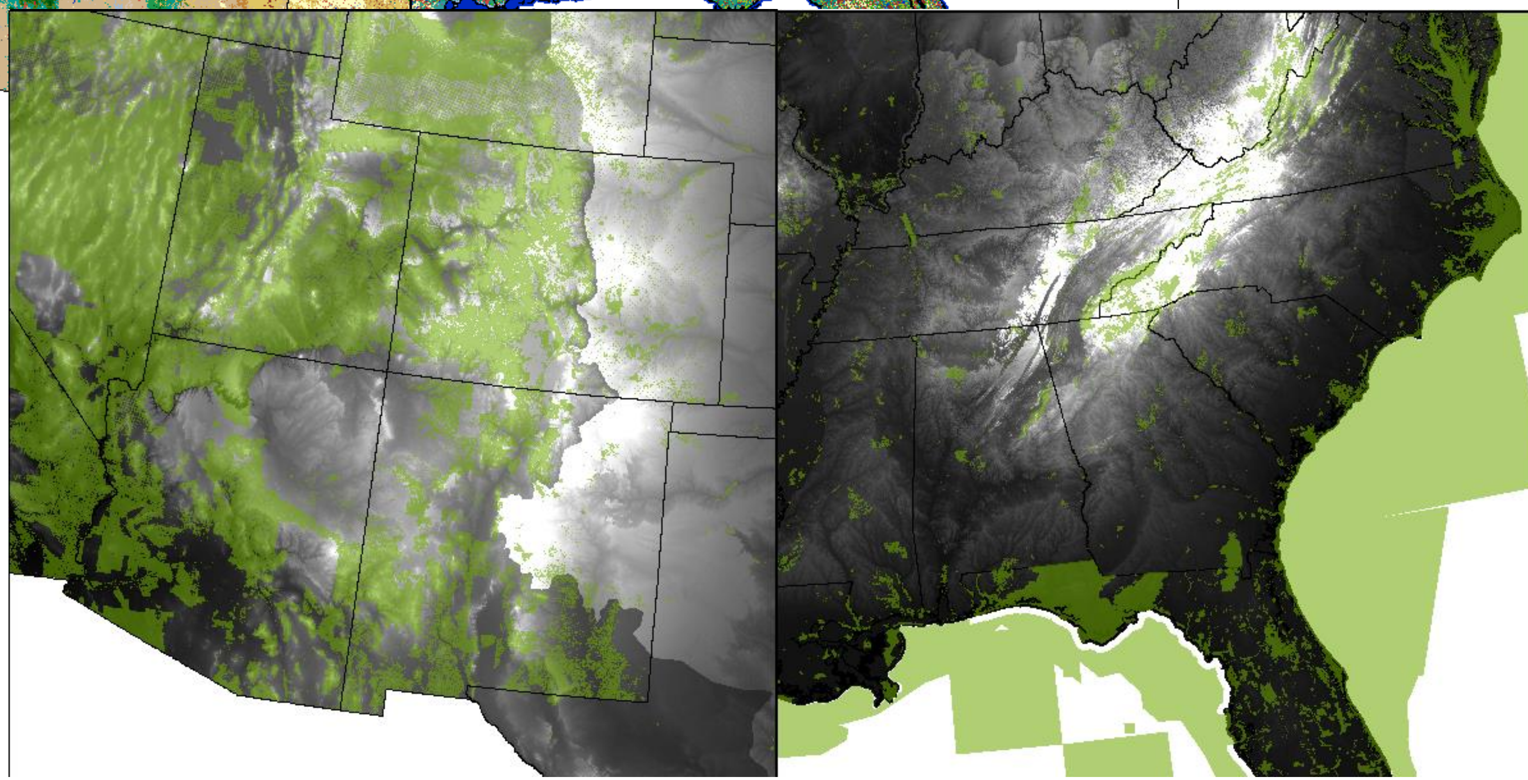
Coupled human-natural systems are influenced by processes occurring at multiple spatial, temporal, and governance scales



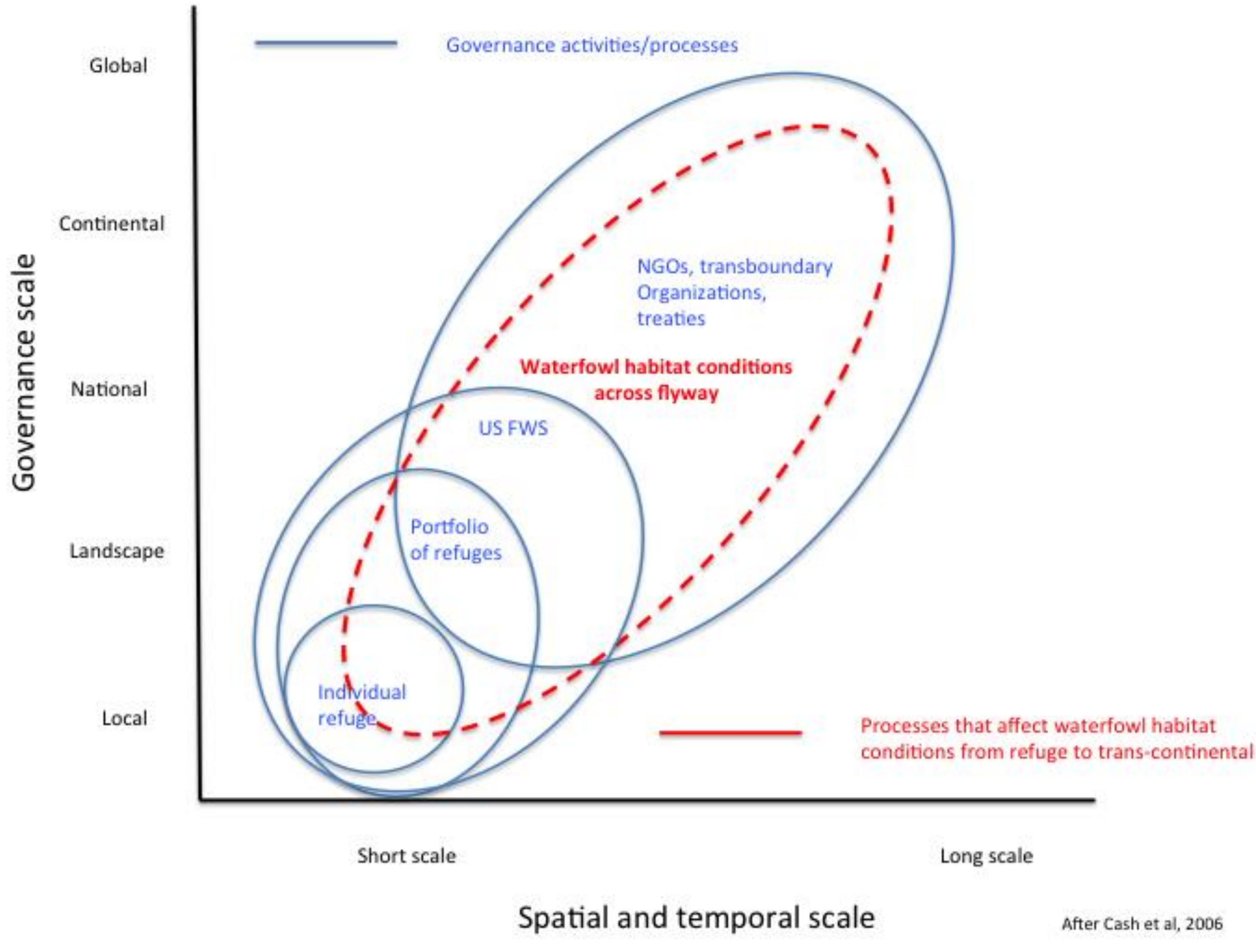
Source: Cahoon, USGS

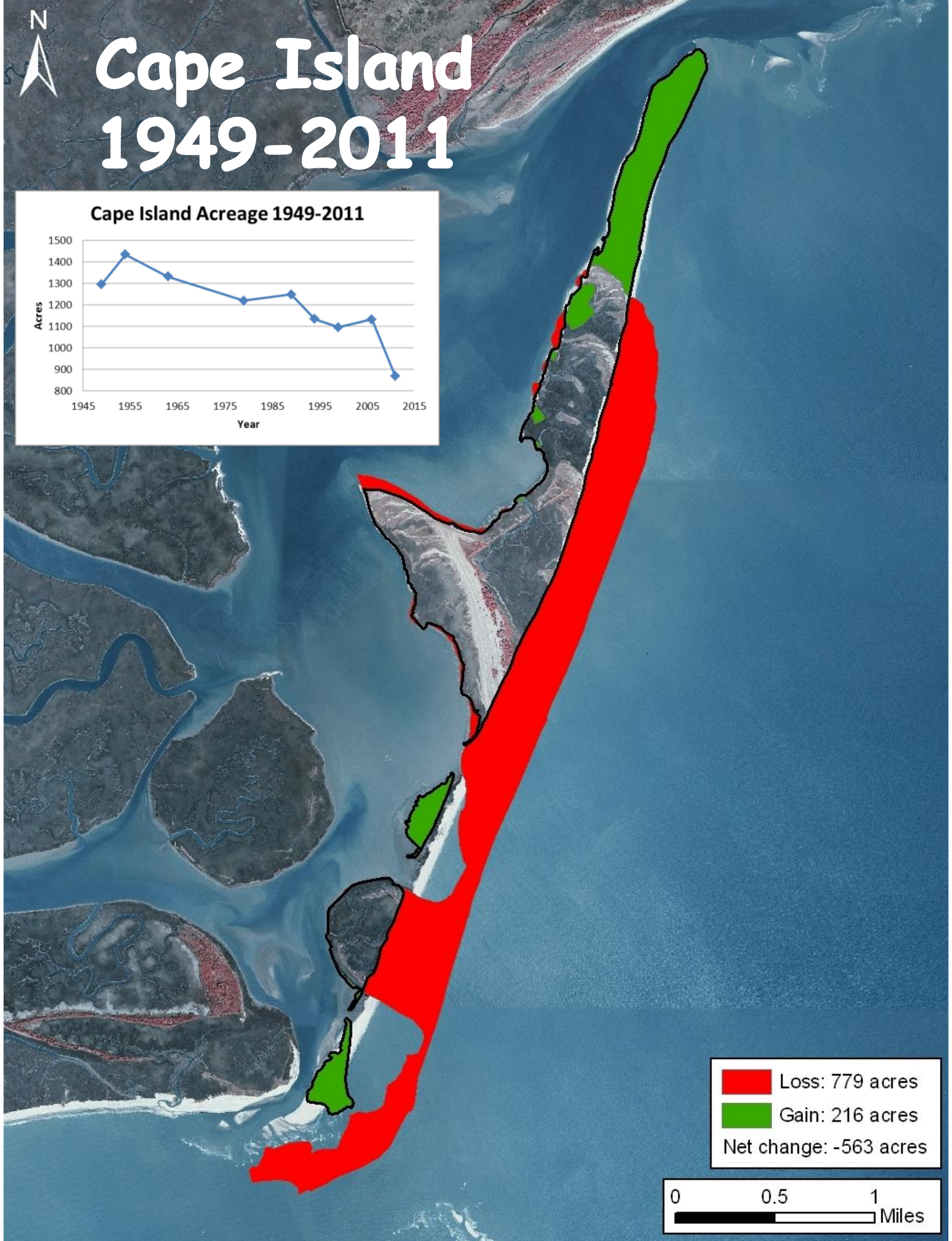


Land cover



Public Lands (green)


Governance activities/processes
Global
Continental
National
Landscape
Local
Governance scale
NGOs, transboundary
Organizations,
treaties
Waterfowl habitat conditions
across flyway
US FWS
Portfolio
of refuges
Individual
refuge
Processes that affect waterfowl habitat
conditions from refuge to trans-continental
Short scale
Long scale
Spatial and temporal scale
After Cash et al, 2006



Framework for adaptation response: continuum of resistance through resilience to transformation (see Stein et al 2013)

Example: Cape Romain NWR SLR/erosion, and loggerhead turtles

General lack of preparation on part of decision makers, scientists, and public for making wise decisions in the face of these challenges

- Mental maps don't account for multi-scale complexity
  - Dealing with broad scale change (space and time) that is noisy at the scale we experience it.
    - E.g., weather versus climate
  - Impressions of change based on recent experience (availability bias)
- Thinking fast-thinking slow
  - Thinking fast: short term recognition of risks and rewards
  - Thinking slow: longer term recognition of risks and rewards
- General scientific literacy
  - Short term (time and space) relations between stressors and response
  - Longer term (time and space) ; see Mental Maps

SECSC "actionable science" niche
(activities that wouldn't happen without the NCSU-USGS collaboration)

- Our understanding of this niche is evolving…
- From primarily "standard" climate science…
  - impacts of climate/land use stressors on endpoints (FY11/12 projects); state of science syntheses
- …toward a "conversation and listening"-directed science model…science focused by what people care about.
  - Continue to discuss and understand the challenges above
  - Decision focused research projects
  - Broader public conversations and education
  - Training the next generation of scientists: GCF program

Thank you!

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GETTING MORE ACTION OUT OF ‘ACTIONABLE SCIENCE’

A decision analytic approach to natural resource management

ACCCNRS
22 Jan, 2014

Mitchell Eaton
SE Climate Science Center

ACTIONABLE SCIENCE

- Following a decade of appeals for 'actionable science' (Palmer, et al. 2005)
  - Science in environmental policy
  - 'more science…better science…communication'

- Concern: more *effective* science

Common 2-step Approach: Scientific Involvement in Management

"More science … better science … effective communication"

(1) Scientist collects information (conducts science) and provides results to managers

(2) Manager uses these results to make wise management decisions

- Intellectual 'displacement behavior'

Integrated Approach: Scientific Involvement in Management

"Effective communication … better science"

- Scientist and manager work together in the decision-making context
- Focus is on information most useful to management decisions
  - Consideration of appropriate scales, including organizational scale
  - Science remains hypothesis-driven
  - Policy alternatives included when designing research to understand system response

DECISION ANALYTIC APPROACH

1. Problem Framing

- Decision maker(s) & stakeholders
- Values → fundamental objectives
- Matching of scales
- Alternative Actions

2. Consequences

- Predictive Models
  - link actions to objectives
- Key uncertainties

3. Identify Preferred Policy

- Integration of parts
- Trade-off analysis (optimization)

ILLUSTRATION BY EXAMPLE

Golden eagle management, Denali National Park

Aquila chrysaetos

DECISION ANALYTIC APPROACH

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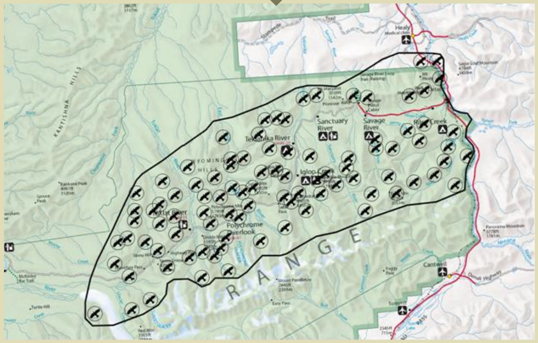
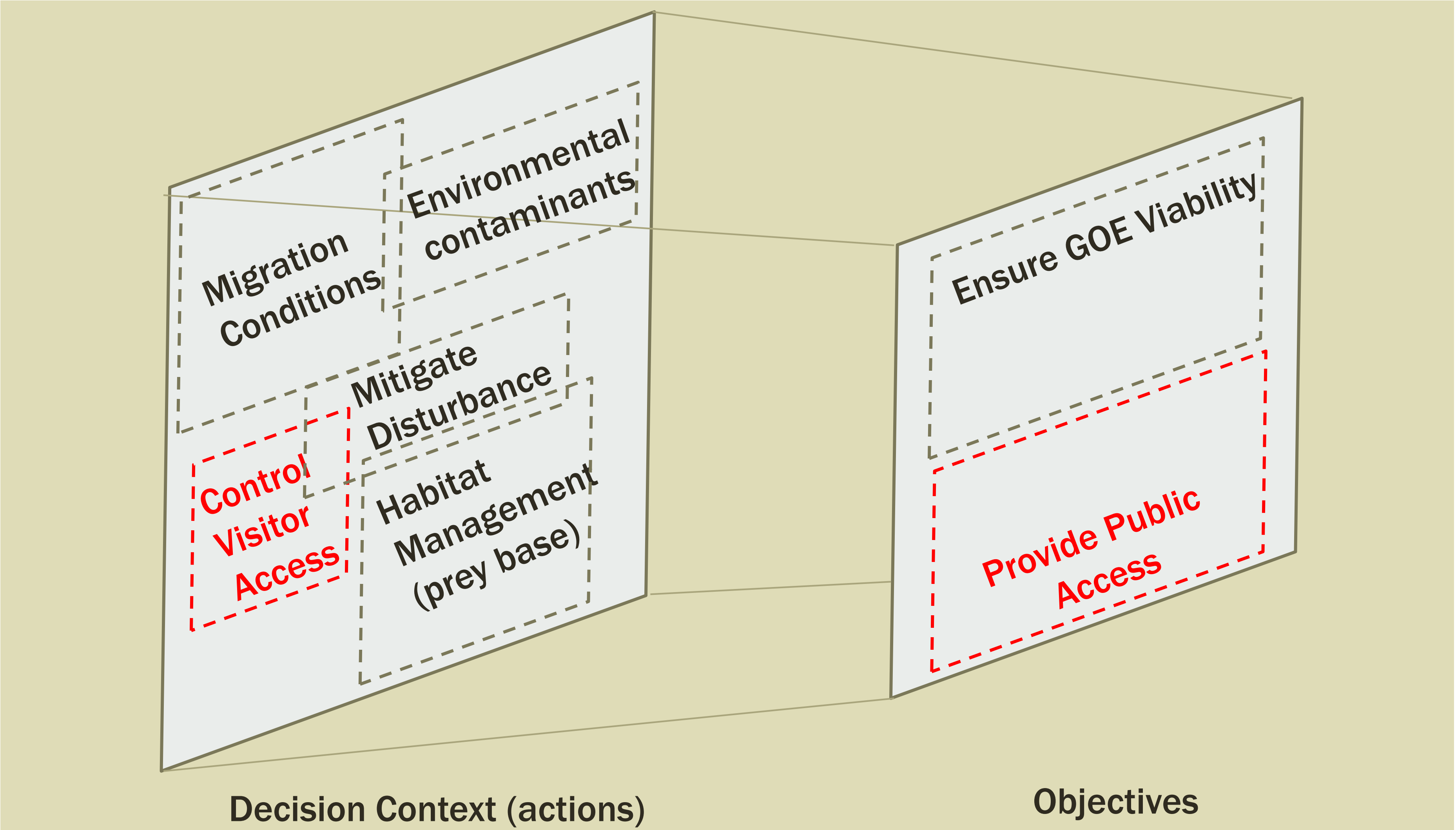


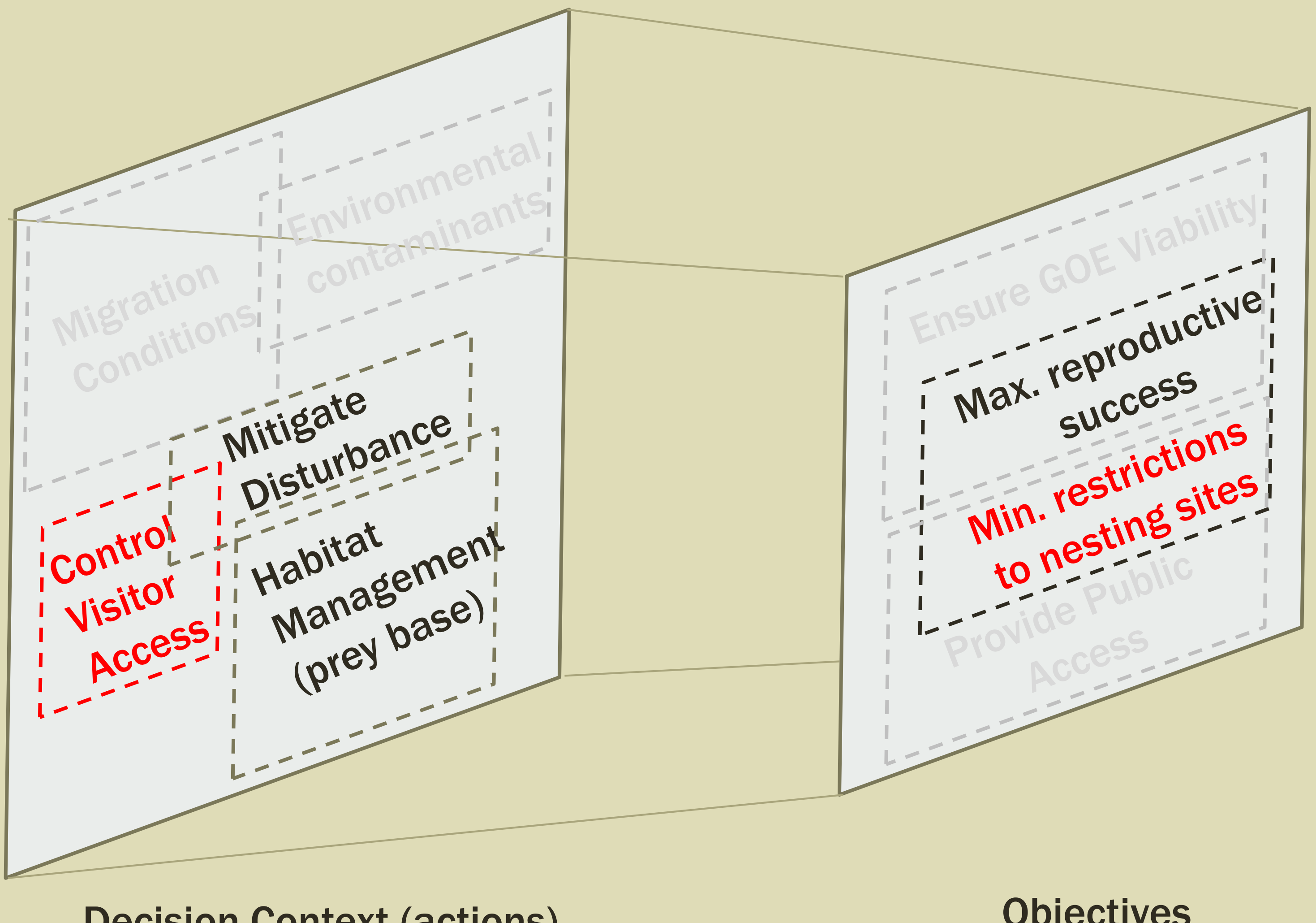
Framing challenges for Denali NP

- Spatial, ecological & governance scale mismatch

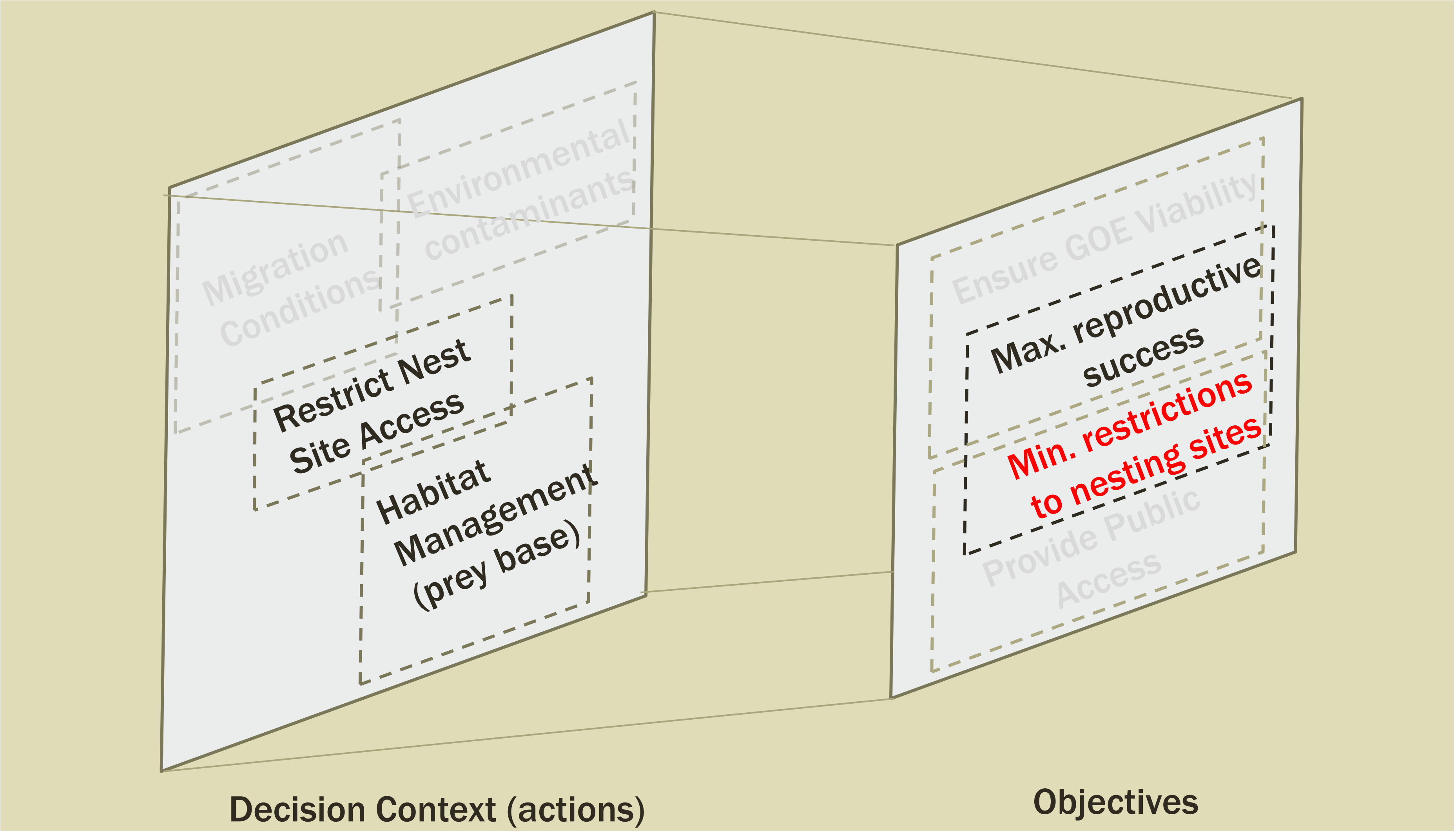
PROBLEM FRAMING – DECISION CONTEXT



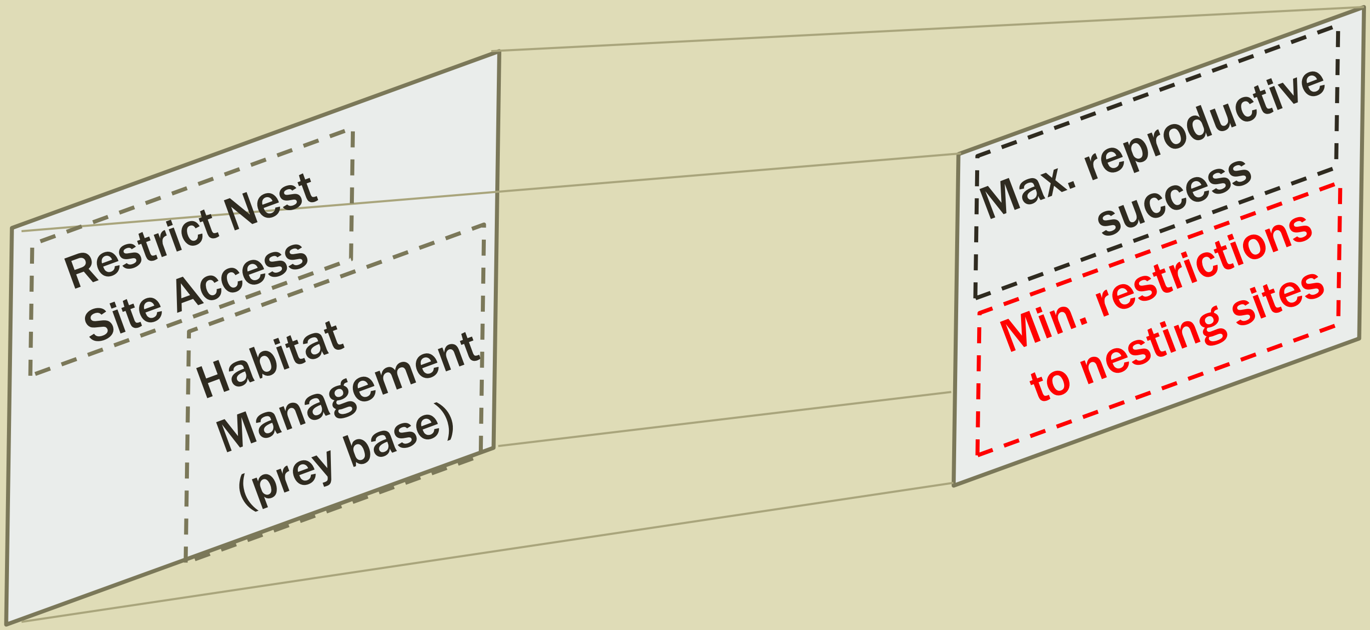
PROBLEM FRAMING – DECISION CONTEXT



PROBLEM FRAMING – DECISION CONTEXT



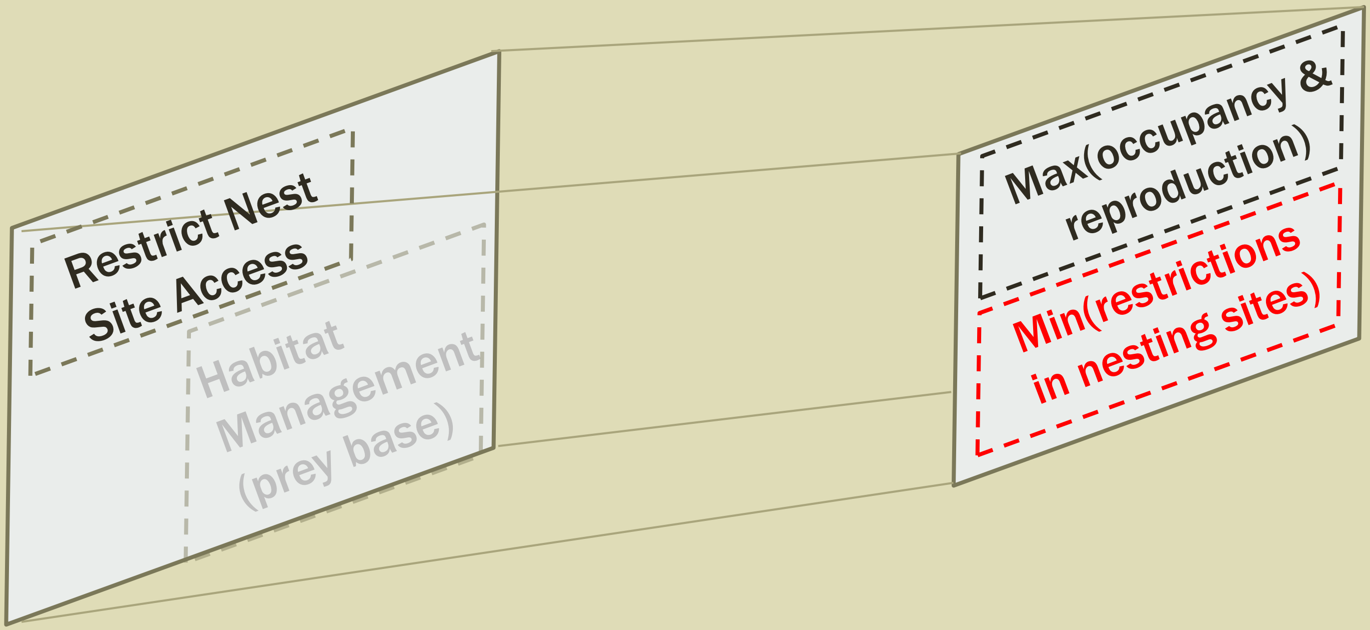
PROBLEM FRAMING – DECISION CONTEXT



Decision Context (actions)

Objectives

PROBLEM FRAMING – DECISION CONTEXT



Decision Context (actions)

Objectives

PROBLEM FRAMING – DECISION CONTEXT

Decision Context (actions)

Objectives

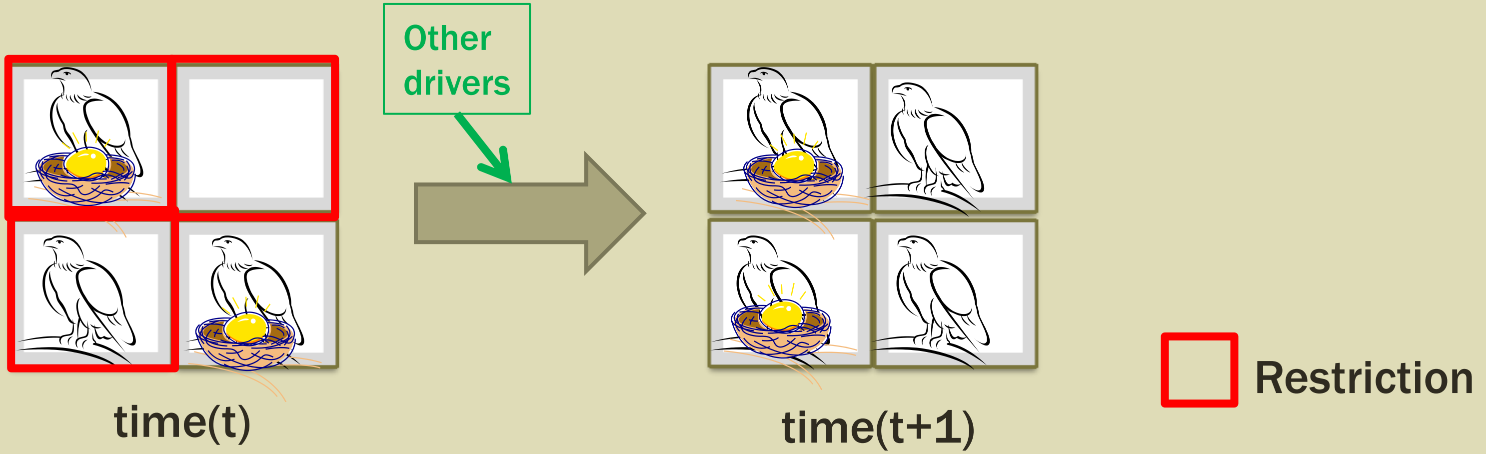
CONSEQUENCES & MODELS

1. Problem Framing

- Decision maker(s) & stakeholders
- Values/objectives
- Risk Attitudes
- Matching of scales
- Alternative Actions

2. Consequences

- Predictive Models
- Uncertainty



CONSEQUENCES & MODELS

- Threshold penalty: $\alpha = \begin{cases} 0, & E_r(N^o_{t+1}) < \tau \\ 1, & E_r(N^o_{t+1}) \geq \tau \end{cases}$
- Utility function: $U_t(N^O_t, r_t) = (90 - r_t) \times \alpha$
- Objective function: $\max \sum_{t=0}^{T} U_t$

State Process Model

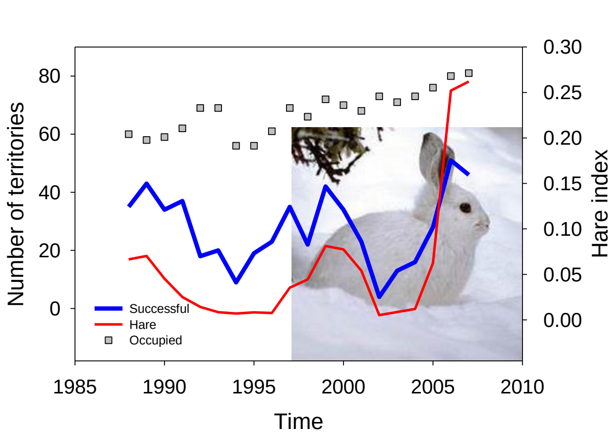
$$\begin{bmatrix} 1-\psi^{[0]}_{t+1} & 1-\psi^{[1]}_{t+1} & 1-\psi^{[2]}_{t+1} \\ \psi^{[0]}_{t+1}(1-R^{[0]}_{t+1}) & \psi^{[1]}_{t+1}(1-R^{[1]}_{t+1}) & \psi^{[2]}_{t+1}(1-R^{[2]}_{t+1}) \\ \psi^{[0]}_{t+1}R^{[0]}_{t+1} & \psi^{[1]}_{t+1}R^{[1]}_{t+1} & \psi^{[2]}_{t+1}R^{[2]}_{t+1} \end{bmatrix}$$

$$(\psi^{[m]}_{t+1}) = \beta_{INT} + \beta_{HARE} \times HARE_t + \beta_{DIST} \times DIST$$

$$Hare = \begin{cases} 0, & \leq \tau \\ 1, & > \tau \end{cases} \qquad DIST = \begin{cases} 0, & \text{site\_restriction} \\ 1, & \text{no\_restriction} \end{cases}$$

Detection process model

$$logit(p_t) = \beta_1 + \beta_2(Date) + \beta_3(Date)^2$$



SOLUTION: OPTIMIZATION/TRADE-OFF

1. Problem Framing

- Decision maker(s) & stakeholders
- Values/objectives
- Risk Attitudes
- Matching of scales
- Alternative Actions

2. Consequences

- Predictive Models
- Uncertainty

3. Identify Preferred Policy

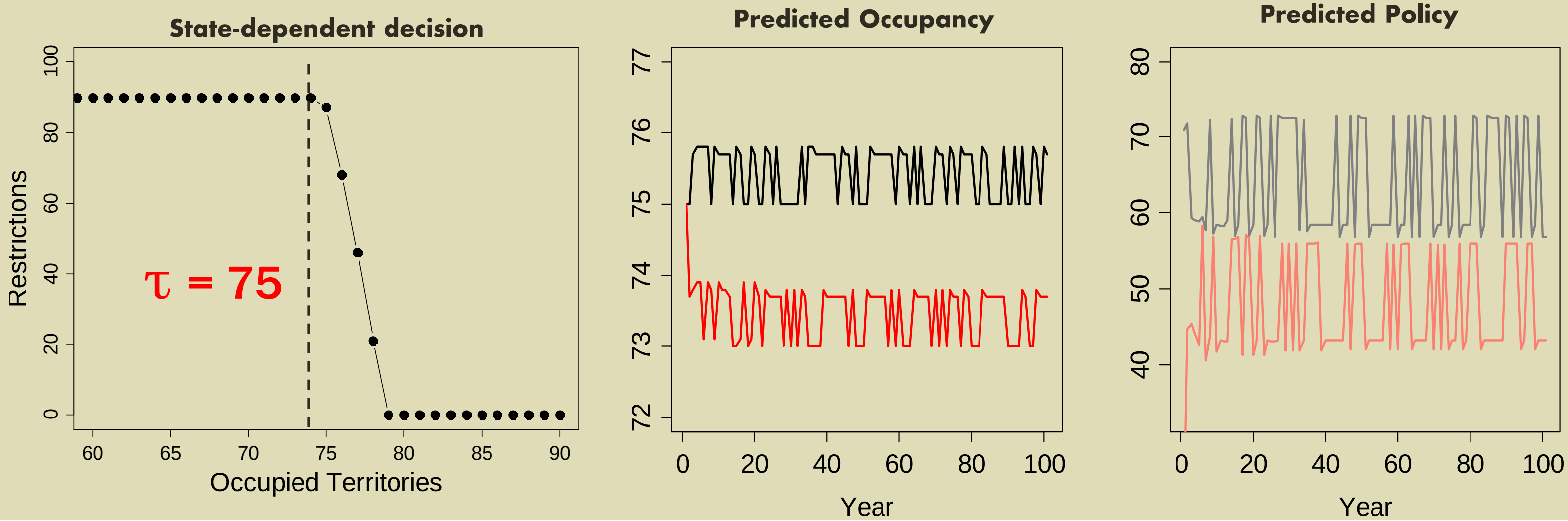
- Integration of parts
- Trade-off analysis (optimization)

Trade-off between conflicting objectives:

- Minimizing nesting disturbance
- Maximizing visitor access

OPTIMIZATION –CHALLENGES

- Annual state-dependent decision
  - Current decision depends on occupancy state of previous year & prediction
  - Recursive optimization to evaluate future returns



BENEFITS OF DECISION ANALYSIS TO ‘ACTIONABLE SCIENCE’

- Collaborative relationship between scientists & policy makers
- Good science

  -Martin, et al. 2009. *Biological Conservation*.
  -Martin, et al. 2011. *Conservation Biology*.
  -Eaton, et al. 2014. in *Application of Threshold Concepts in Natural Resource Decision Making*. Springer.

- Monitoring designed to target decision-related uncertainties.
- Maximize likelihood of implementation
  - Denali NP implemented adaptive management plan in 2012

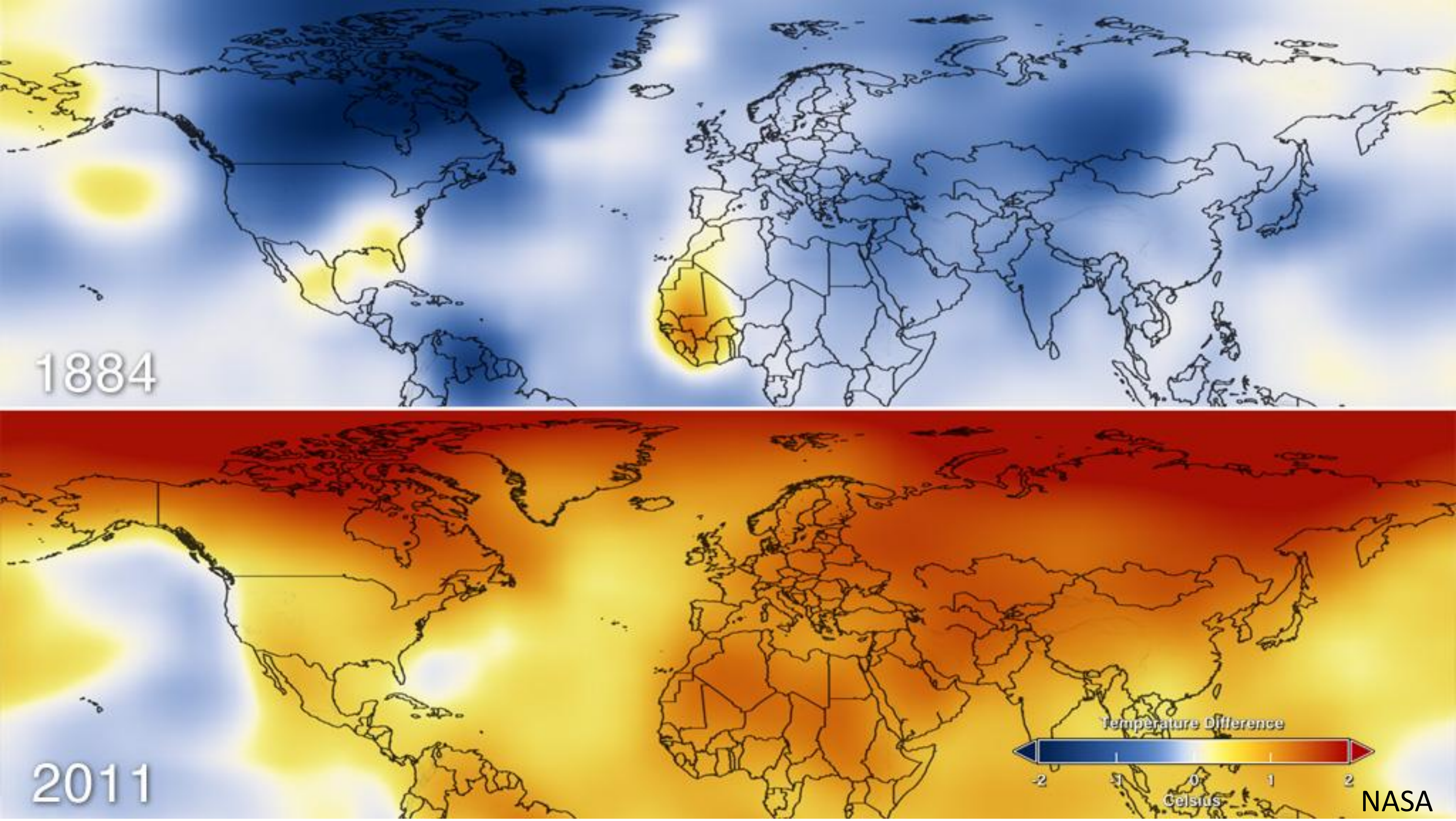
ACKNOWLEDGMENTS

- Julien Martin, FL FWC
- Jim Nichols, USGS-PWRC
- Carol McIntyre & Maggie McCluskie, NPS
- Joel Schmutz, USGS-AK Science Center
- Gerard McMahon, USGS-SECSC

Actionable Climate Science in the Anthropocene

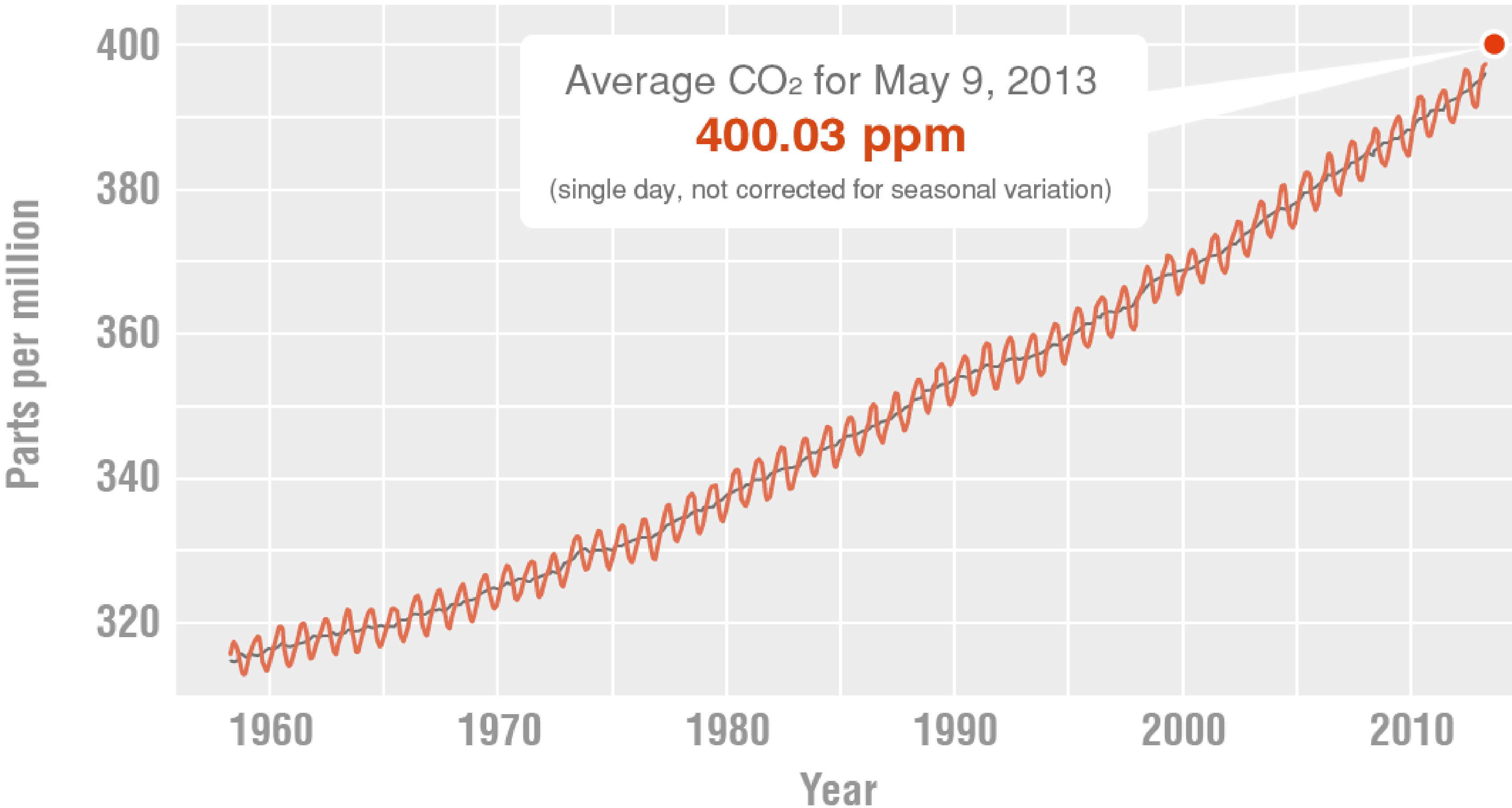
Developing multi-model projections of ecologically and decision-relevant climate variables for Puerto Rico and the US Caribbean.

Adam Terando
U.S. Department of Interior
Southeast Climate Science Center



The Earth is Warming

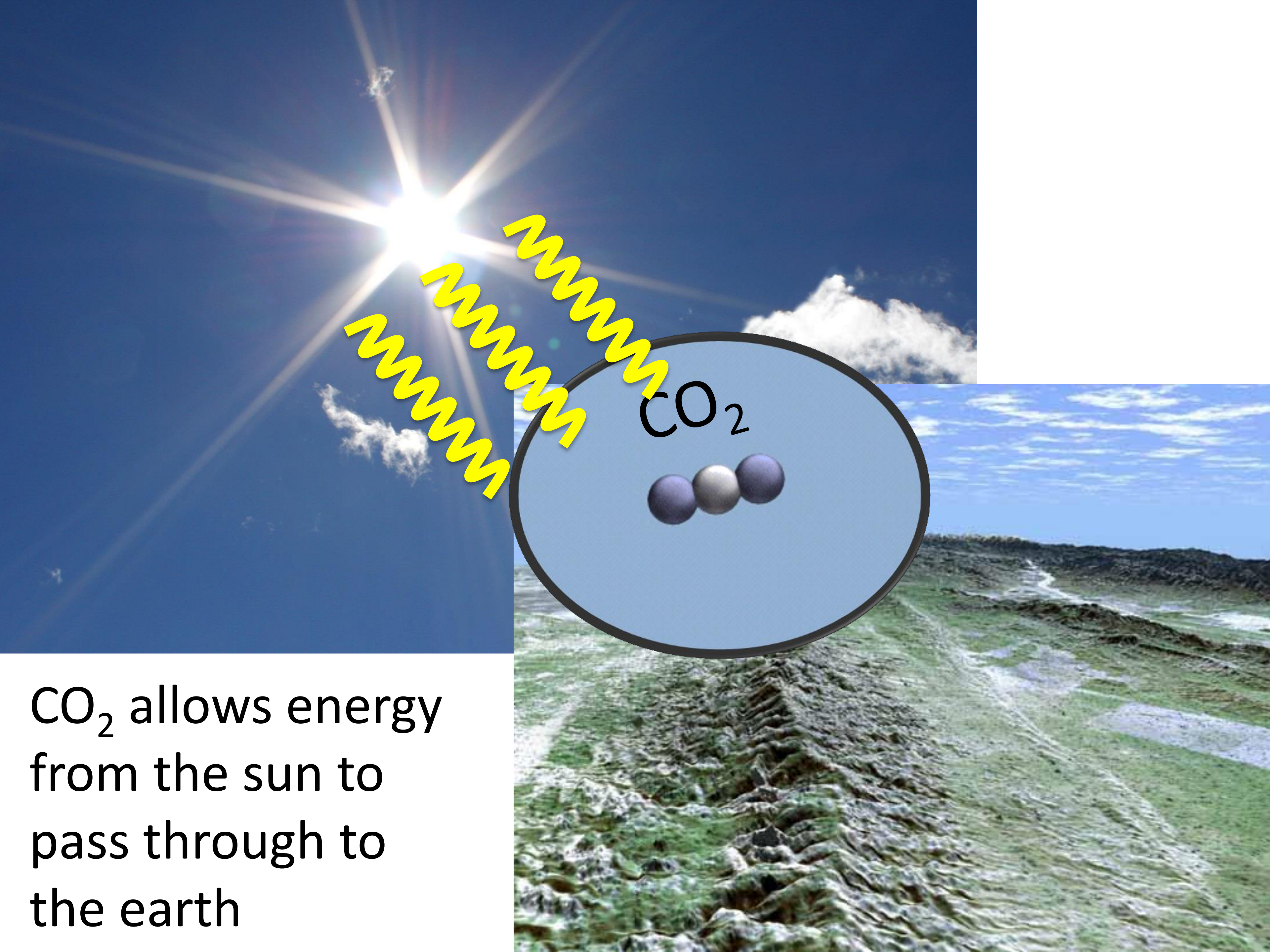
Carbon Dioxide Concentration



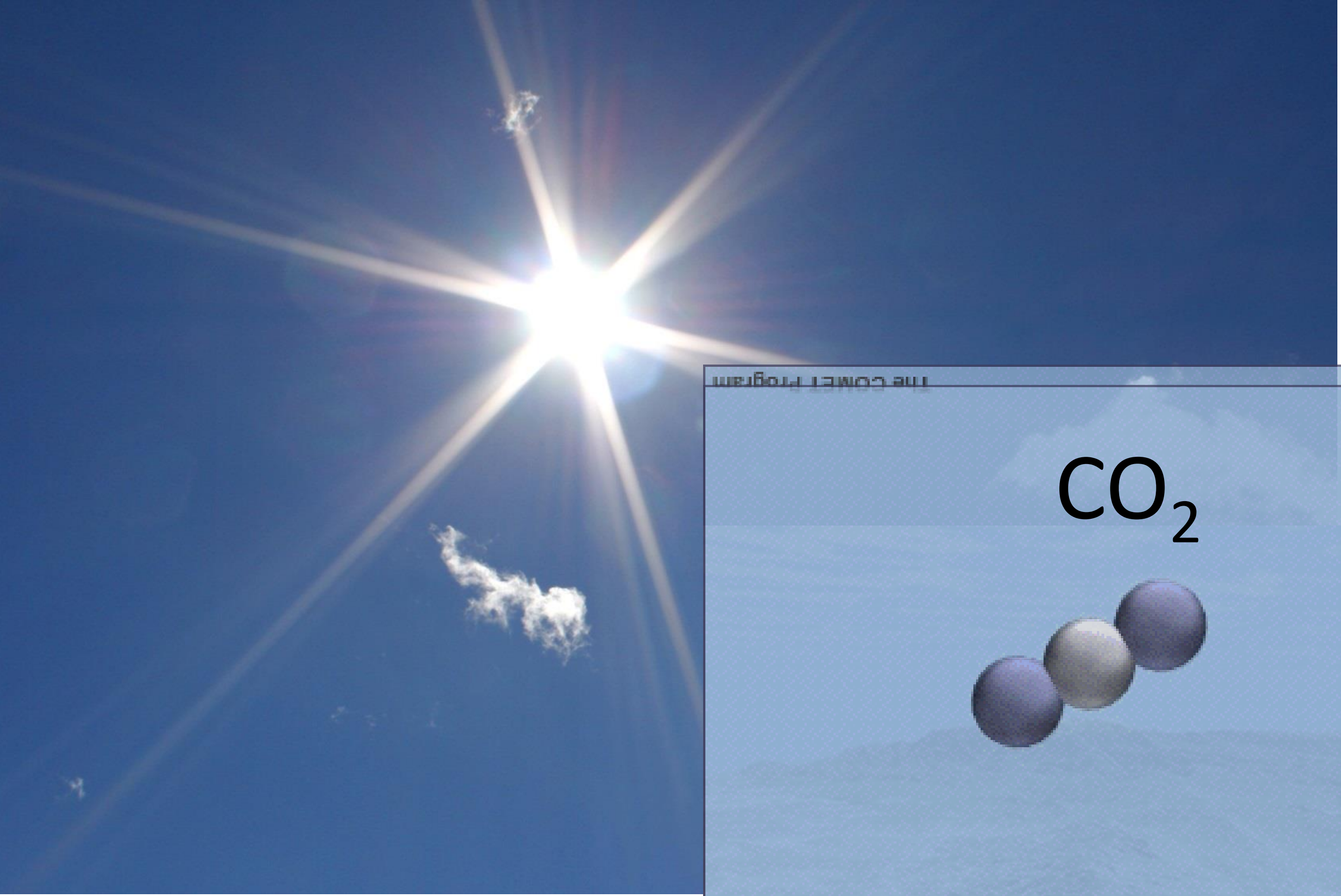
Credit: NOAA/Scripps Institution of Oceanography

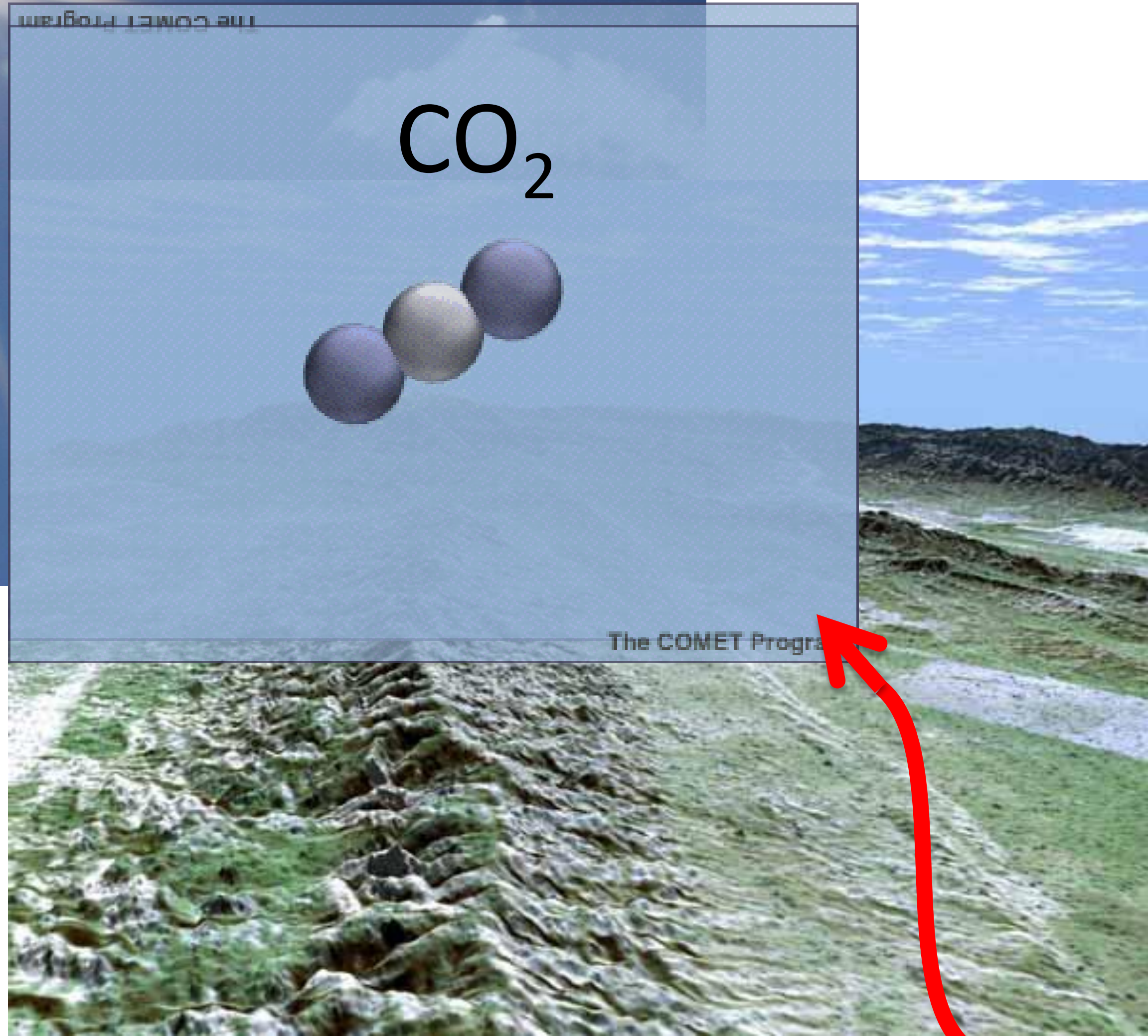
Because there are more greenhouse gases in the atmosphere

Because we burn a lot of fossilized plants

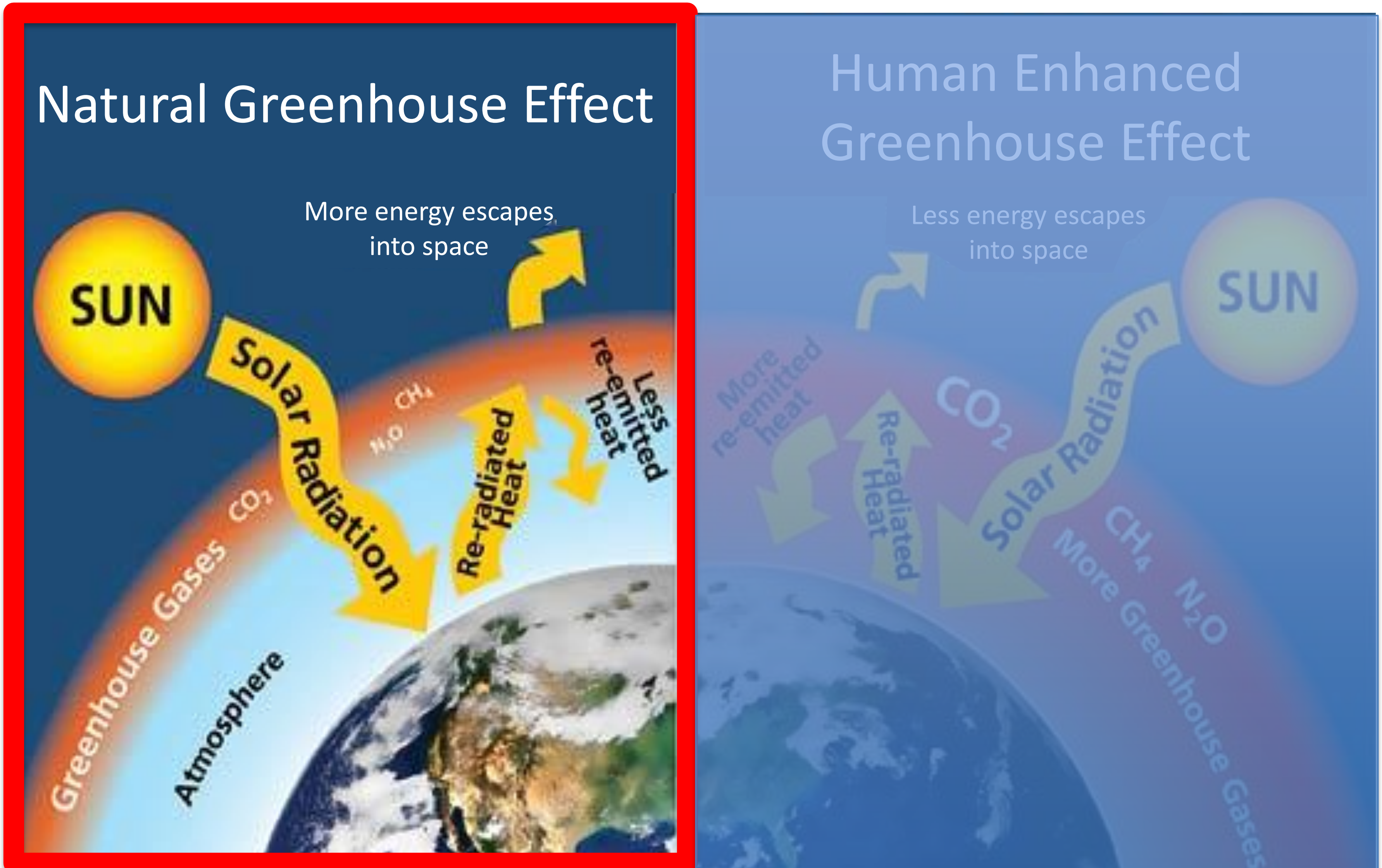


CO_2 allows energy from the sun to pass through to the earth



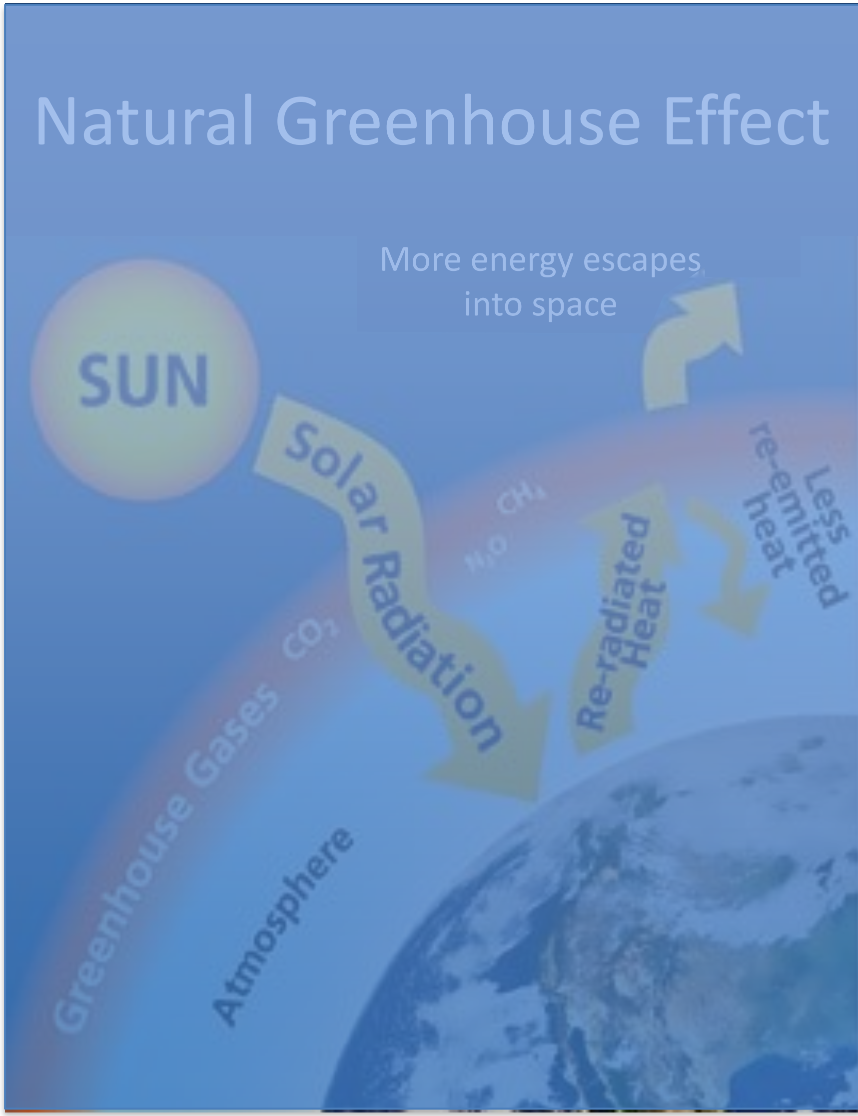


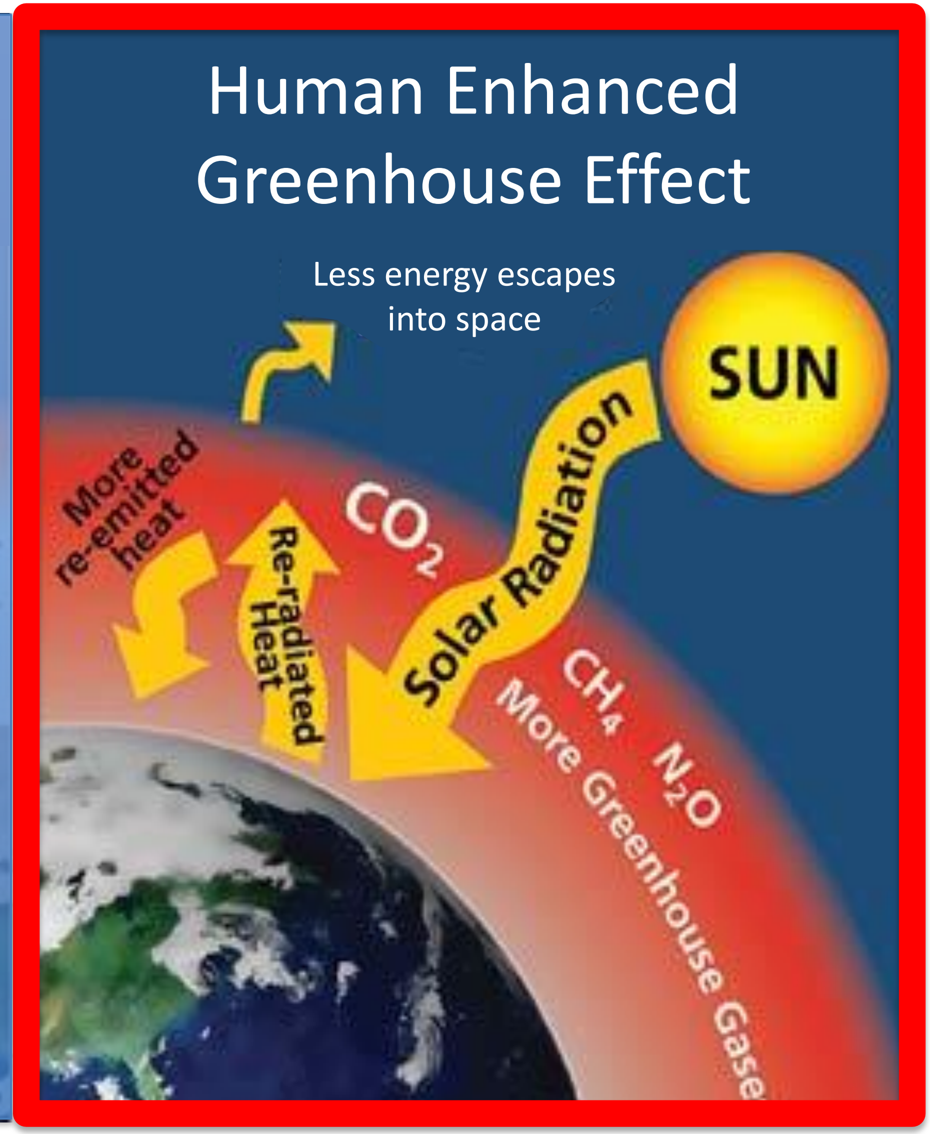
But earth's returning energy is able to excite CO_2…keeps it from escaping to space



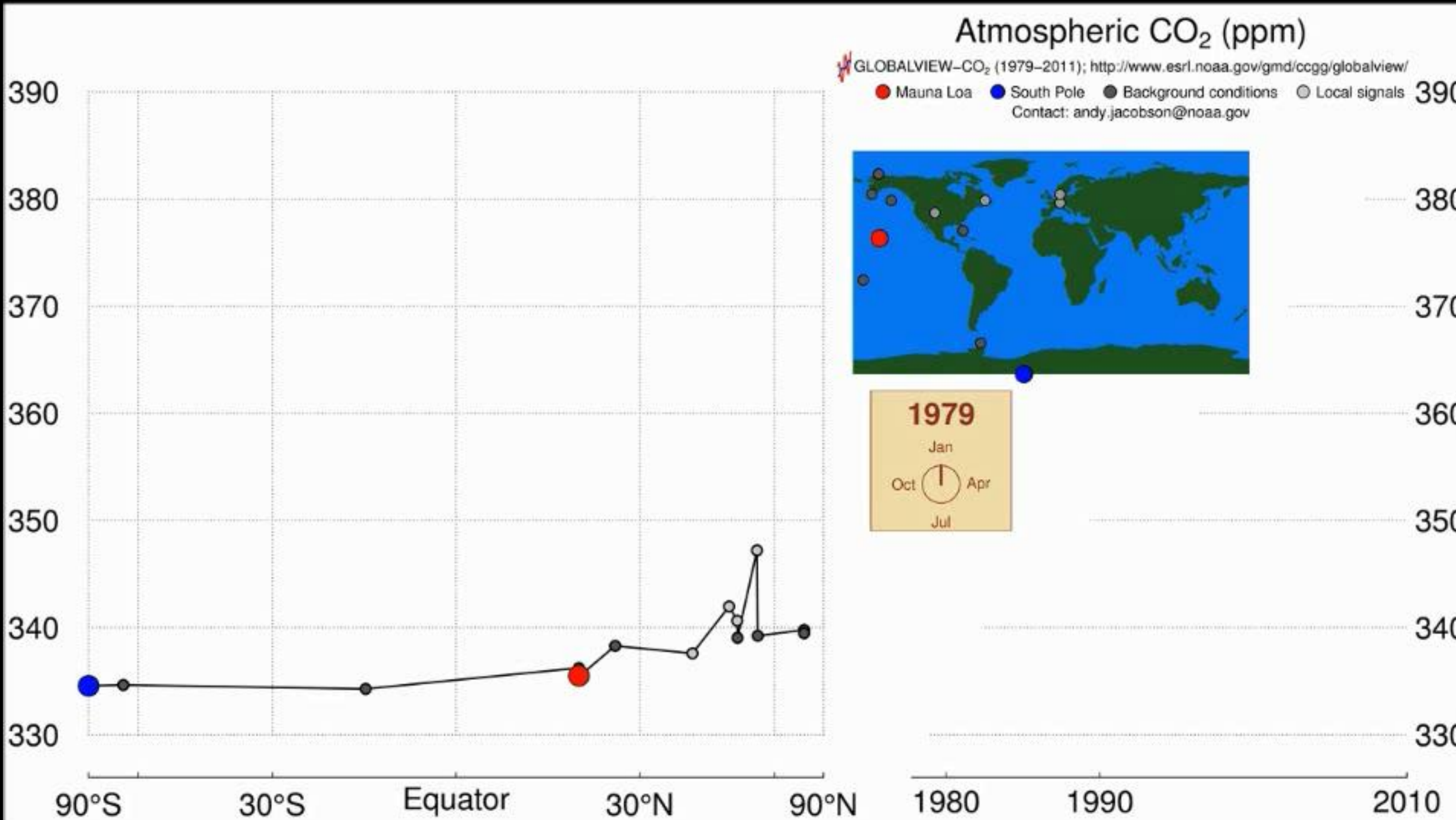
This is the Greenhouse Effect. It is what keeps earth from being an ‘icebox’ planet.

Image: NPS

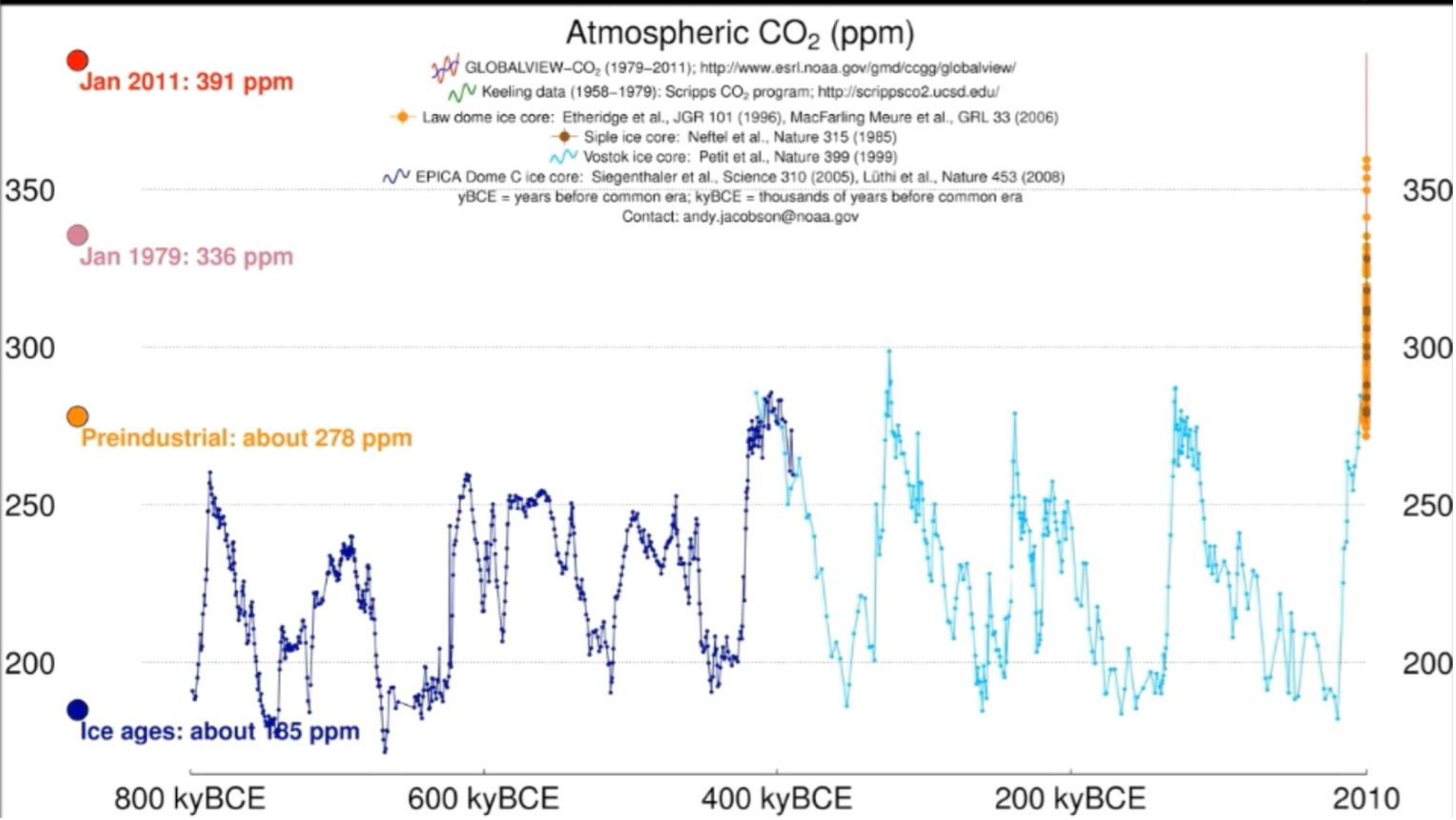




But we are now adding much more CO_2 into the atmosphere which makes this effect stronger.



And now CO_2 in atmosphere may be higher than any point in last ***3 million*** years.



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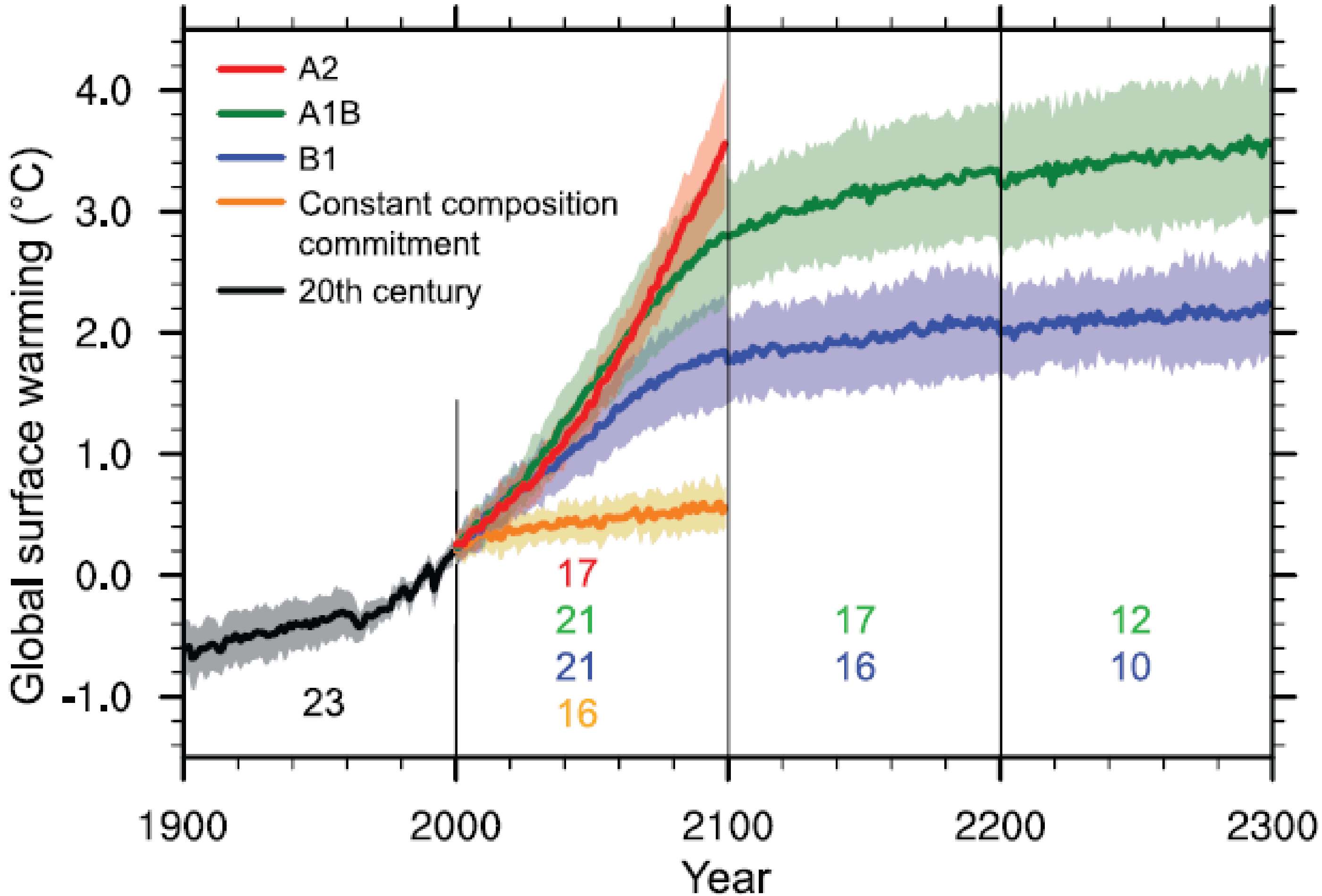
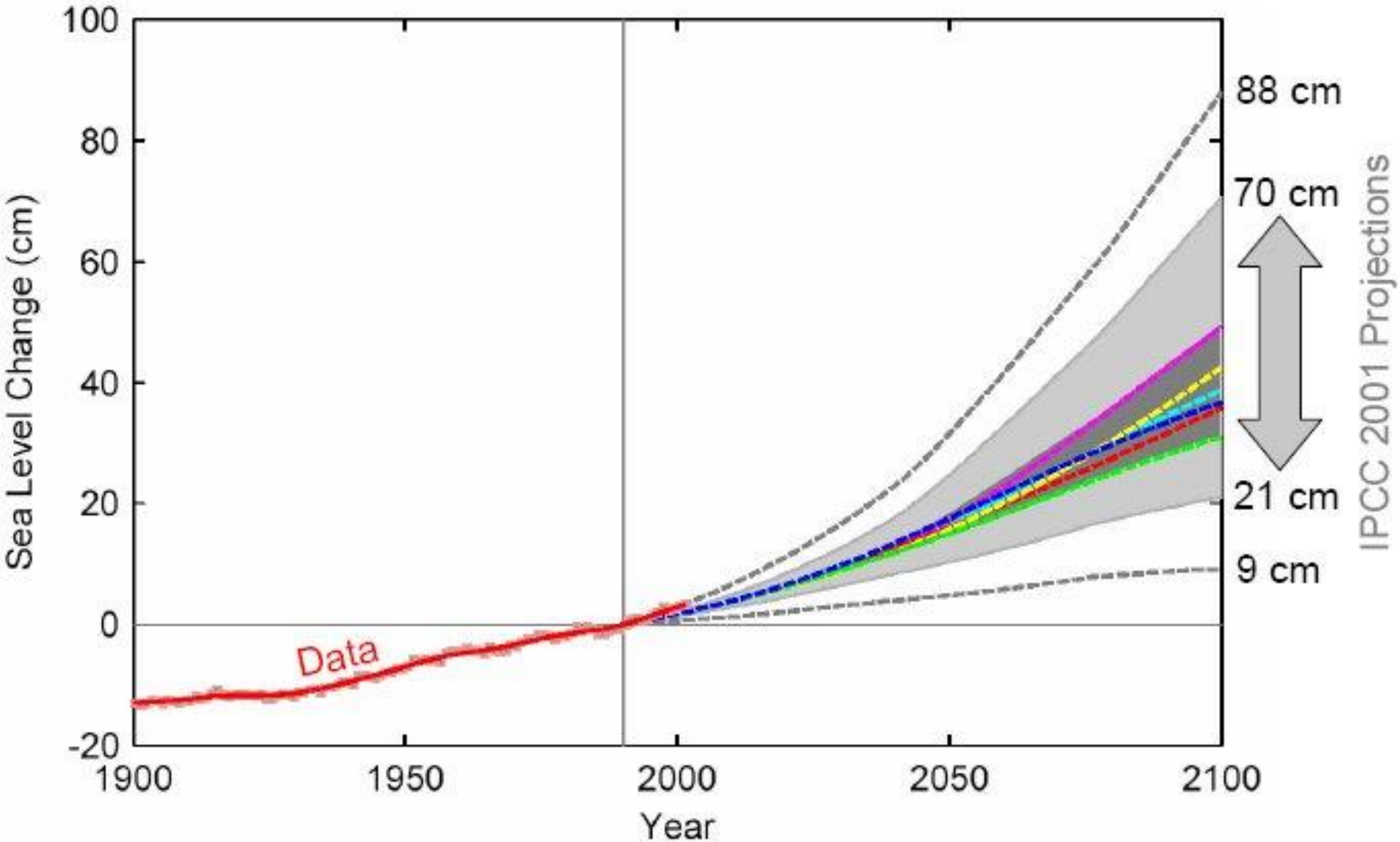


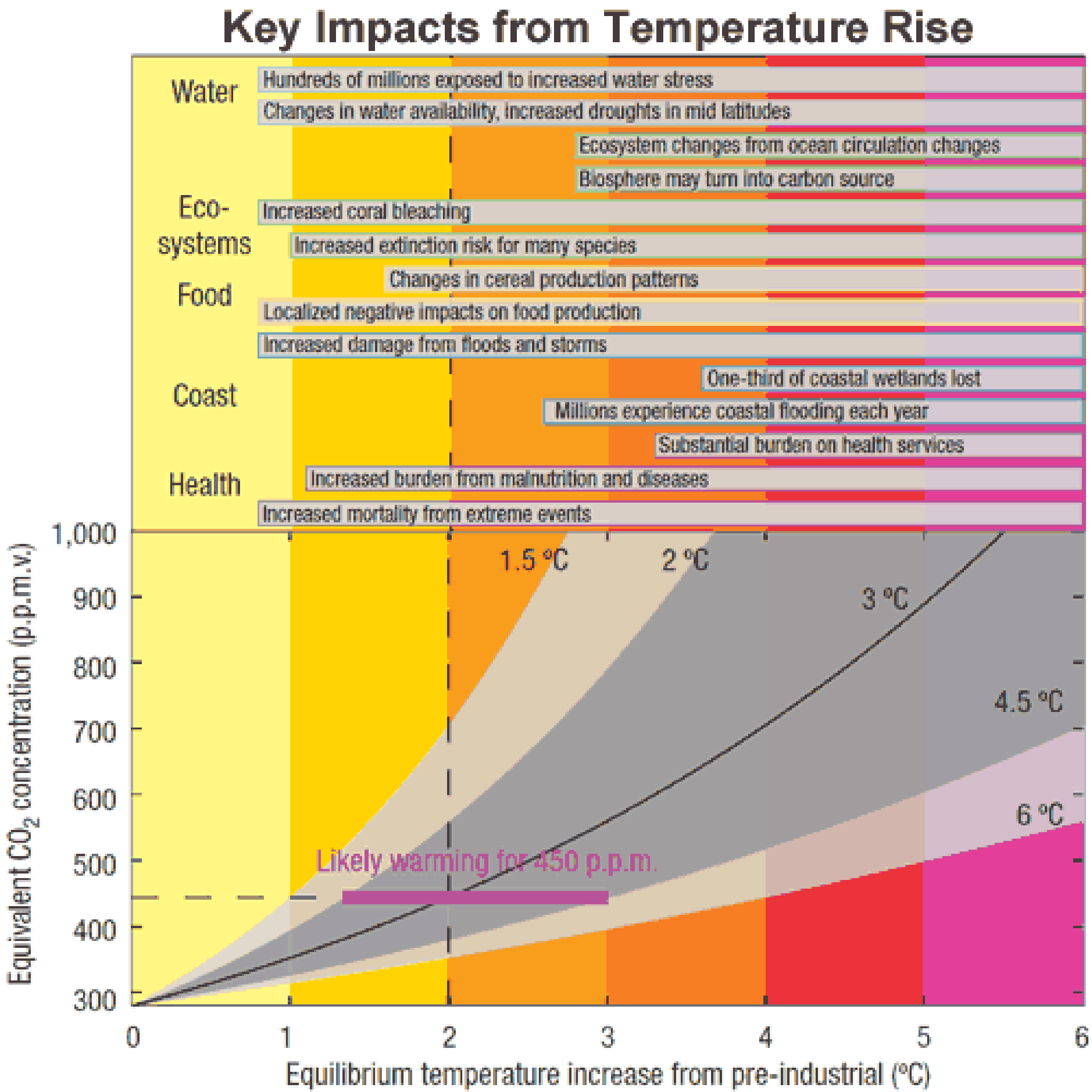
Which leads to a warmer planet.

IPCC AR4 2007



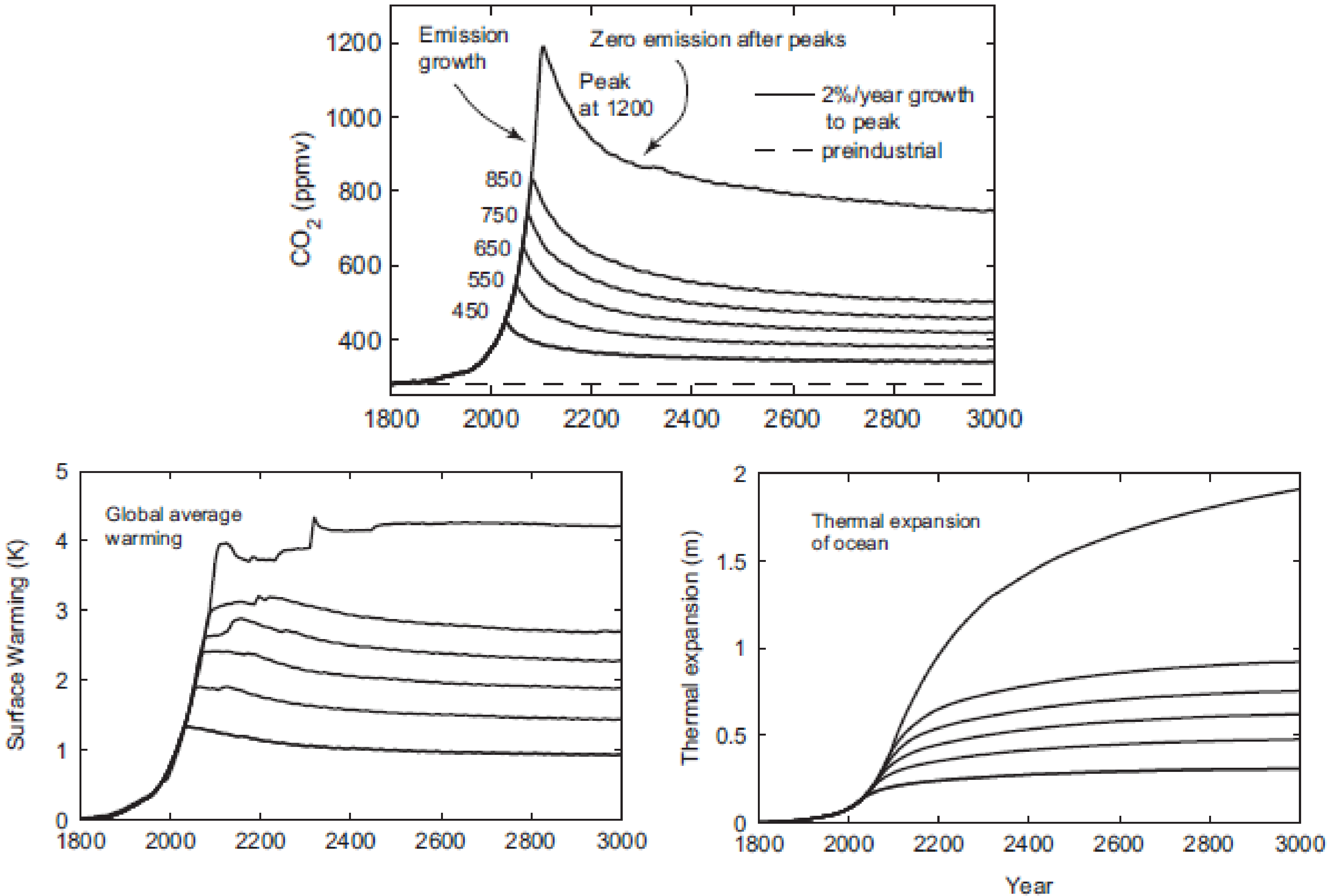
And rising oceans.

Realclimate.org

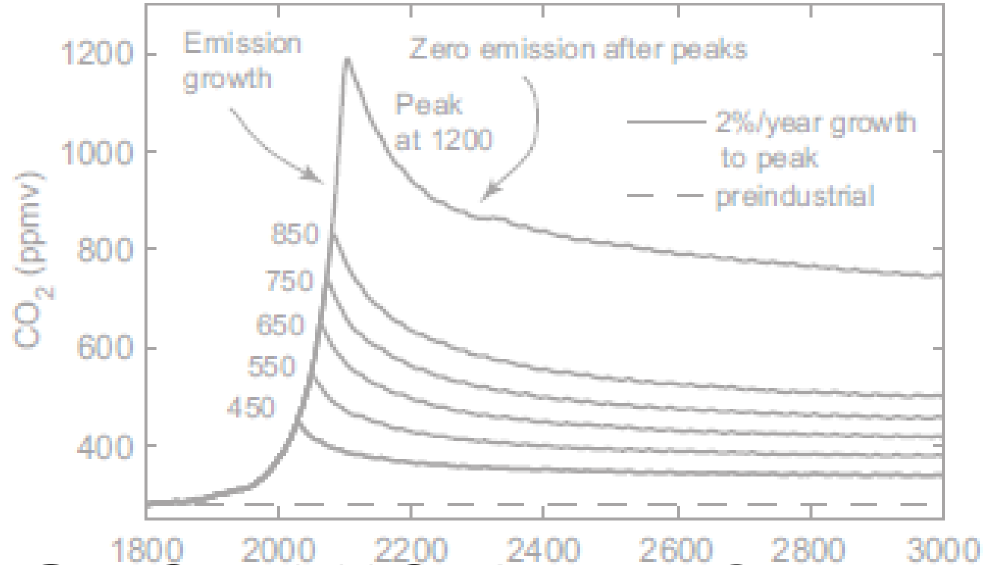


Both of which will lead to all sorts of impacts.

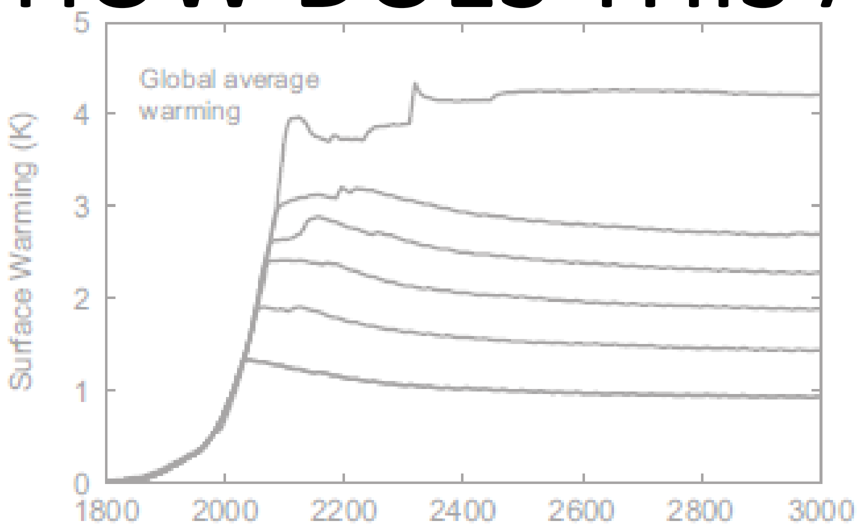
WHERE ARE WE HEADING?

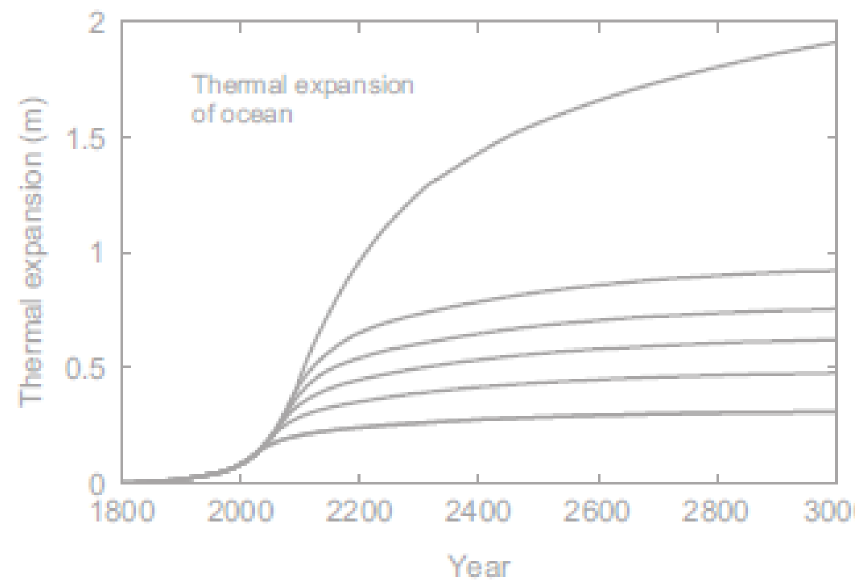


Solomon et al. 2009, PNAS



HOW DOES THIS AFFECT DECISIONS?

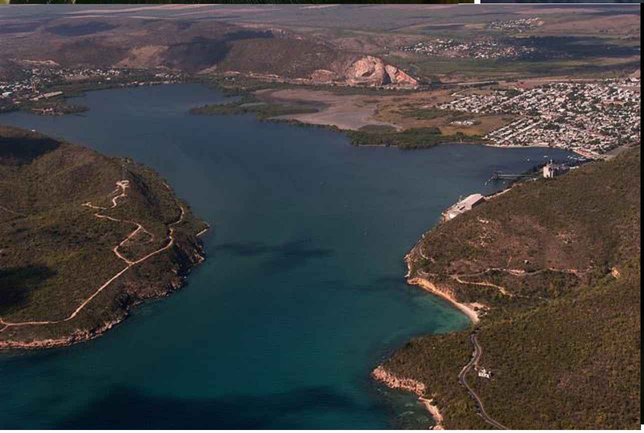




Solomon et al. 2009, PNAS

Conservation Design and Habitat Conservation in Puerto Rico

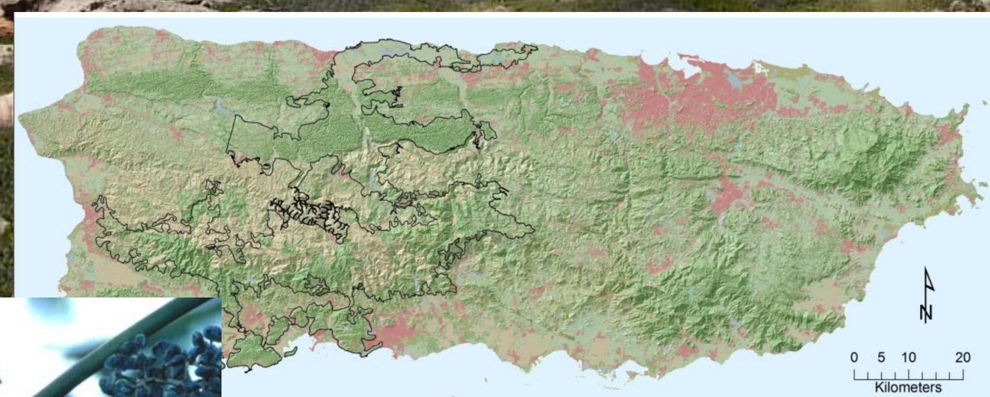


OBJECTIVES

Increase conservation areas from 8% to 15%

Species persistence

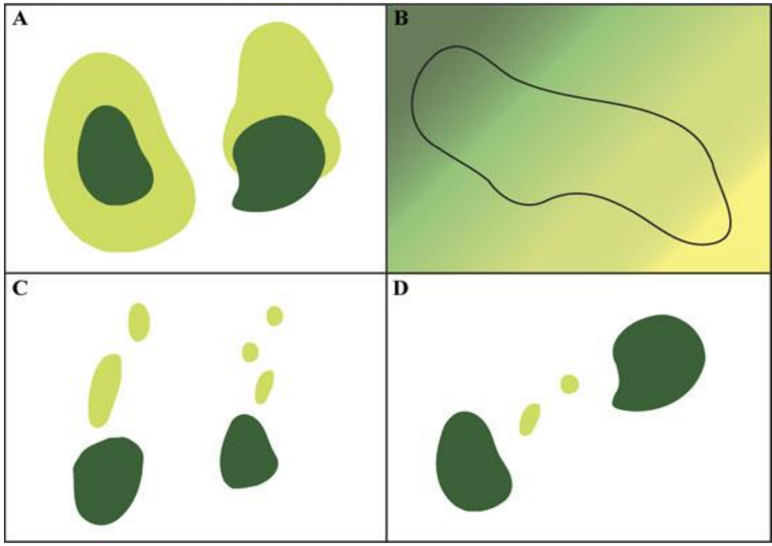


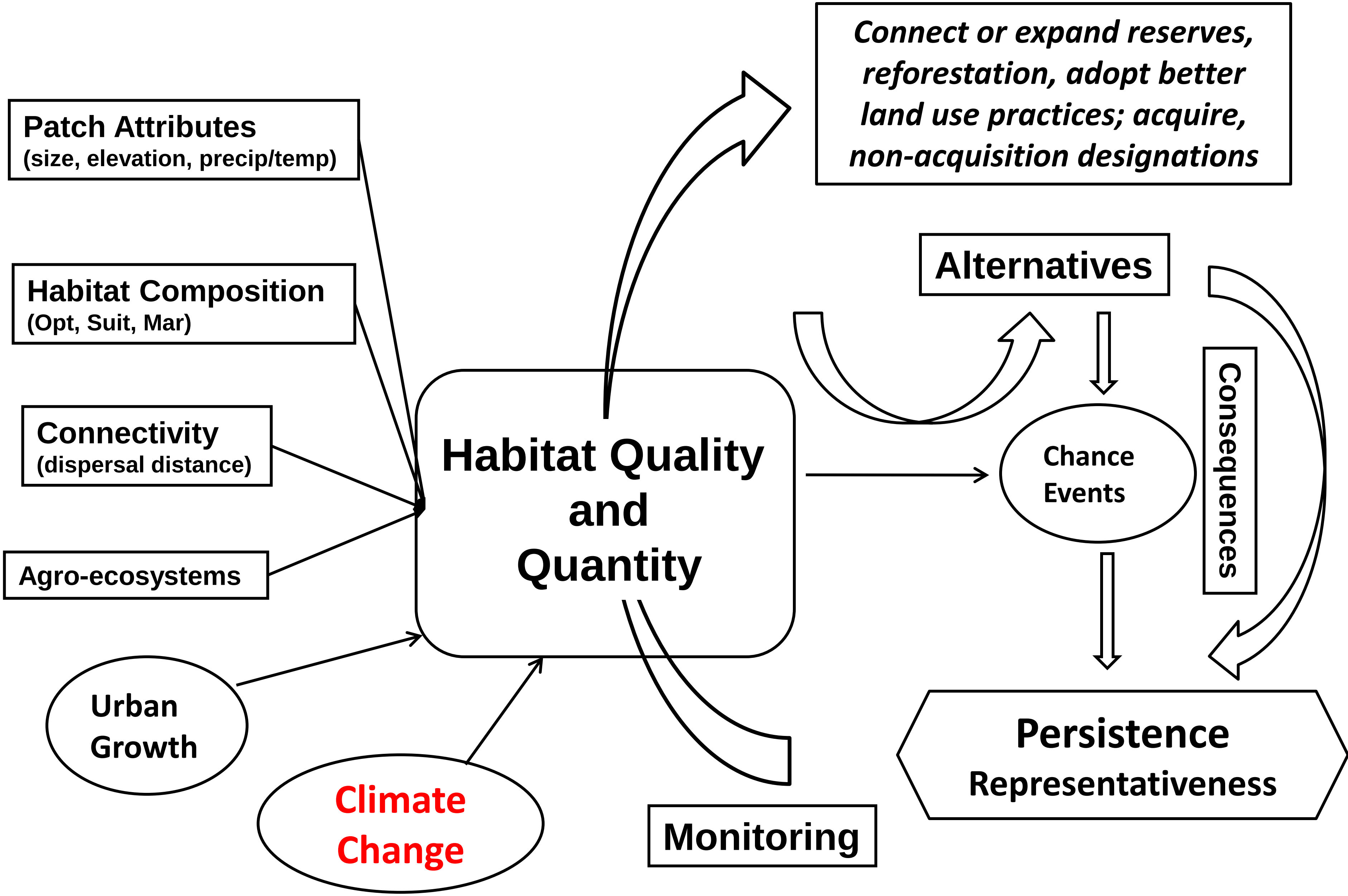
OBJECTIVES

Preserve representative habitat

Develop Decision Framework to Optimally Allocate Conservation Efforts

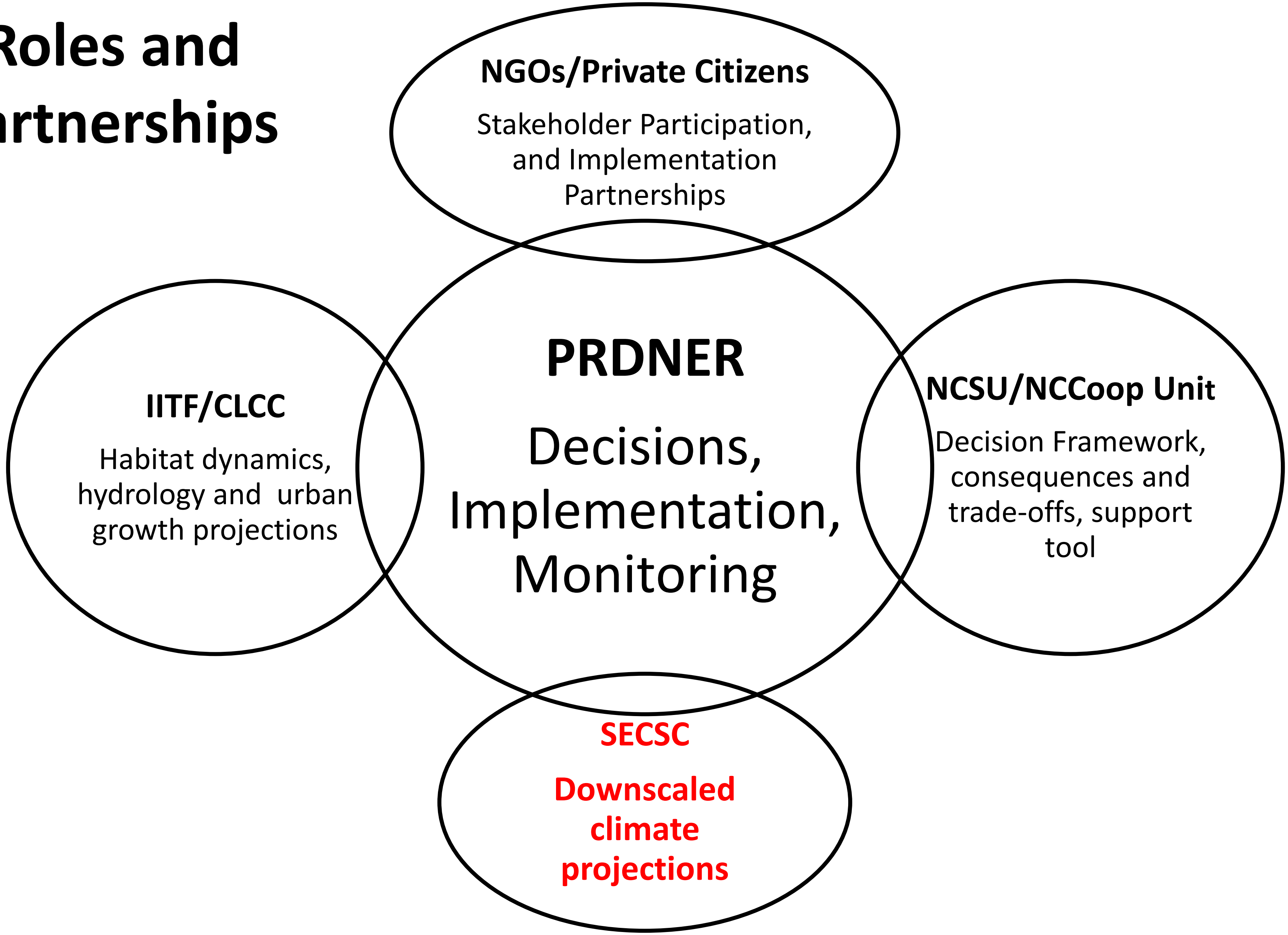
Where and when do we manage?



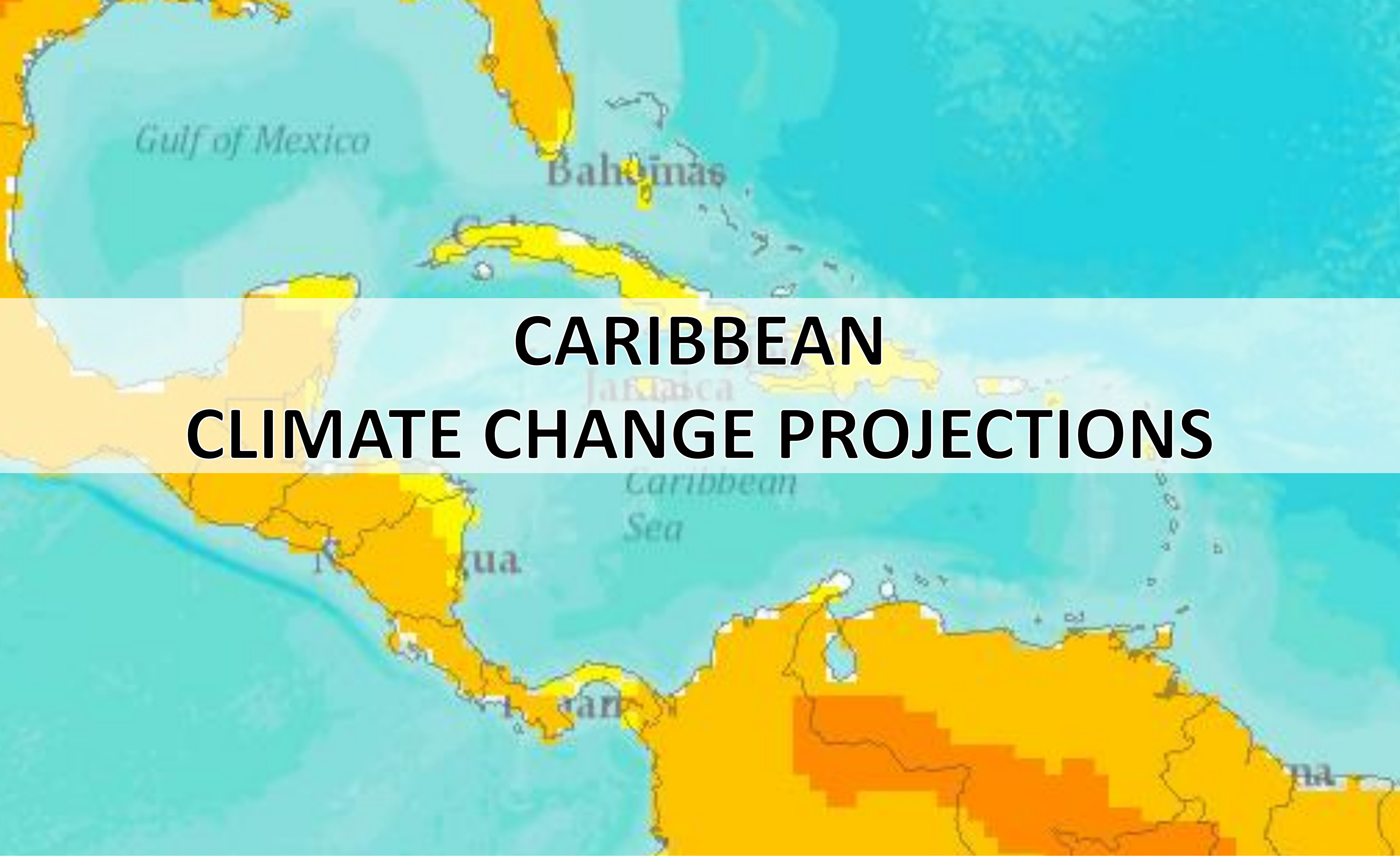


LINKING ALTERNATIVES AND OBJECTIVES

Roles and Partnerships



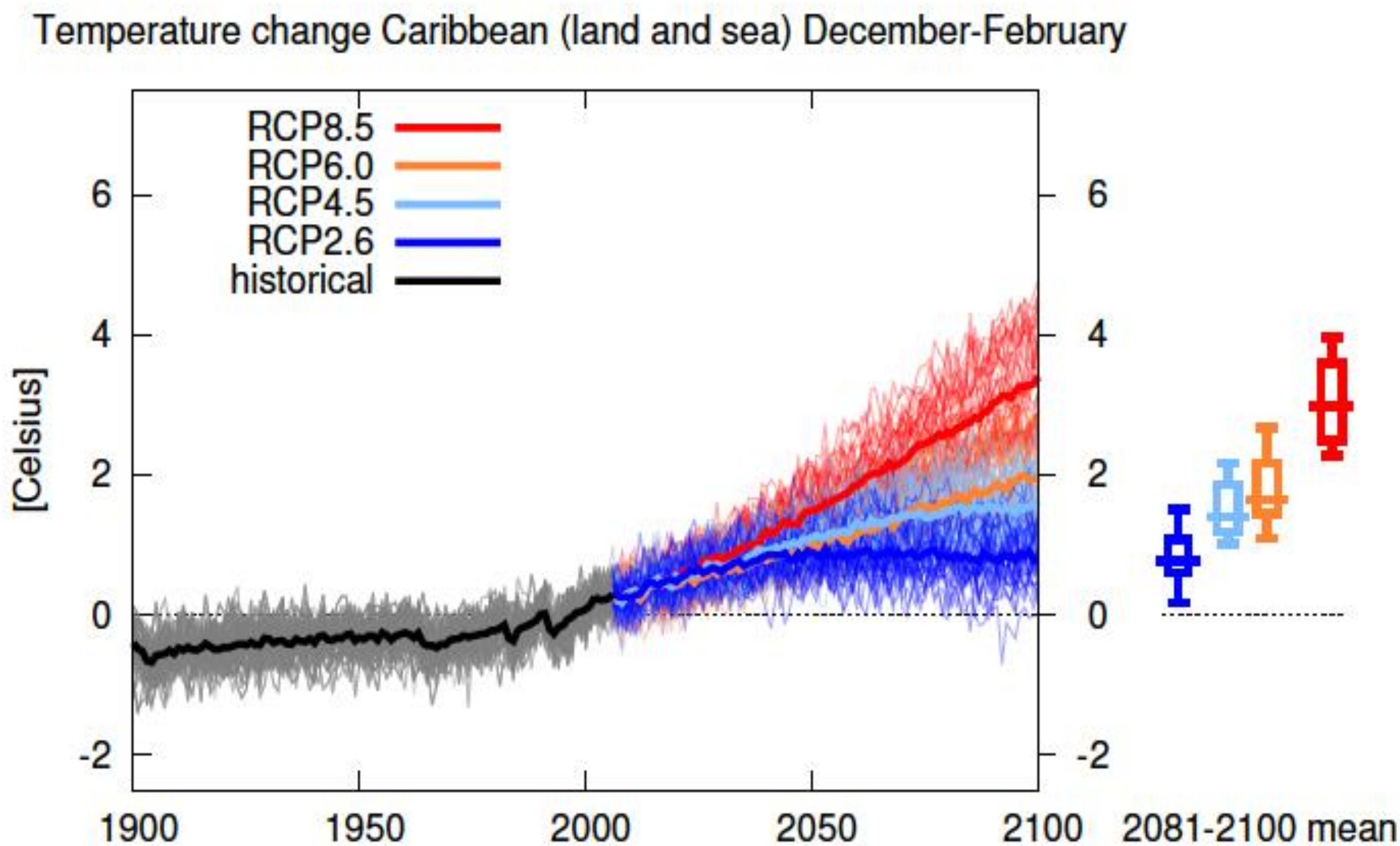
CARIBBEAN
CLIMATE CHANGE PROJECTIONS



Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, iPC, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community

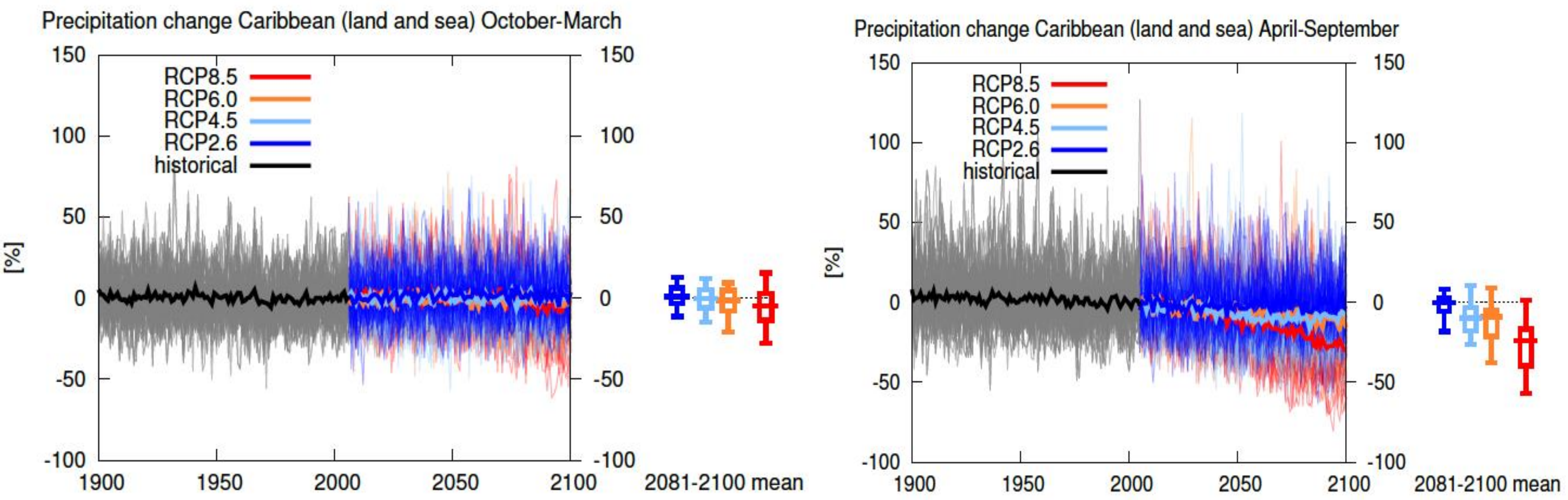
Data Source: Historical Global 50km: Climatic Research Unit and the Tyndall Centre. Mitchell et. al.
http://cru.csi.cgiar.org/PDF/mitchelljones.pdf

1-4^{o}C INCREASE BY 2100

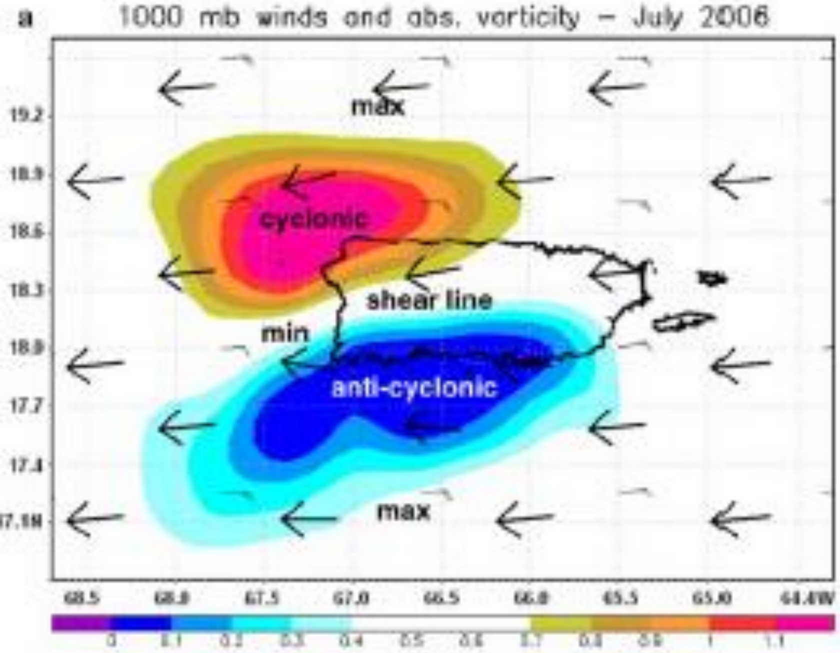


WARMER TEMPERATURES

Current model consensus is for less precipitation

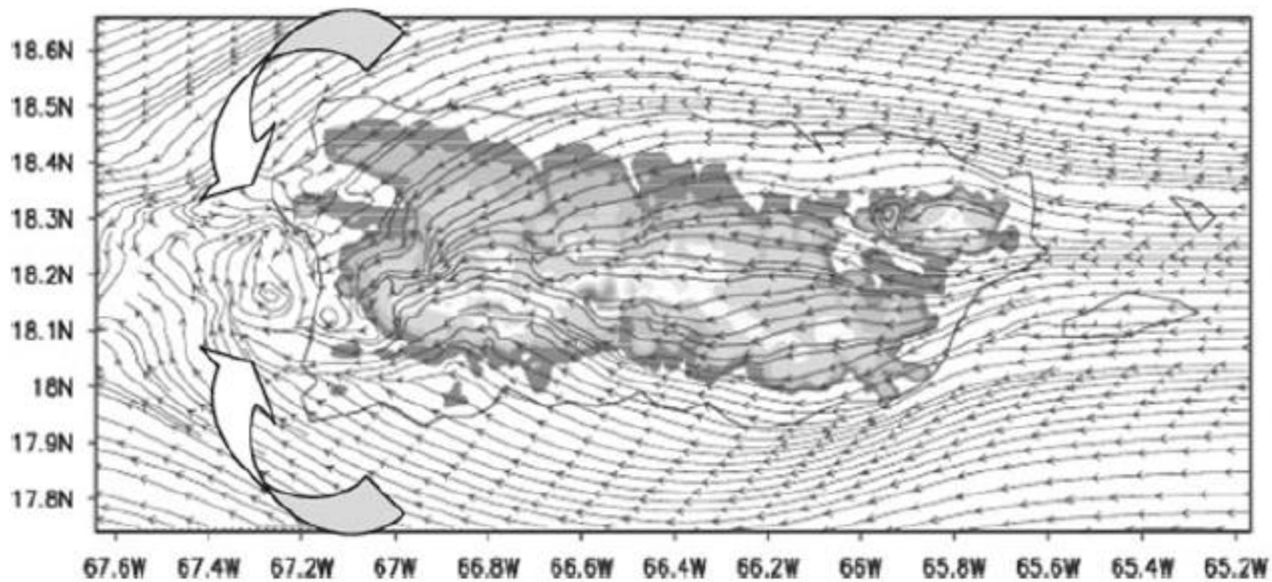


…AND (possibly) DRIER AS GLOBAL TEMPS RISE

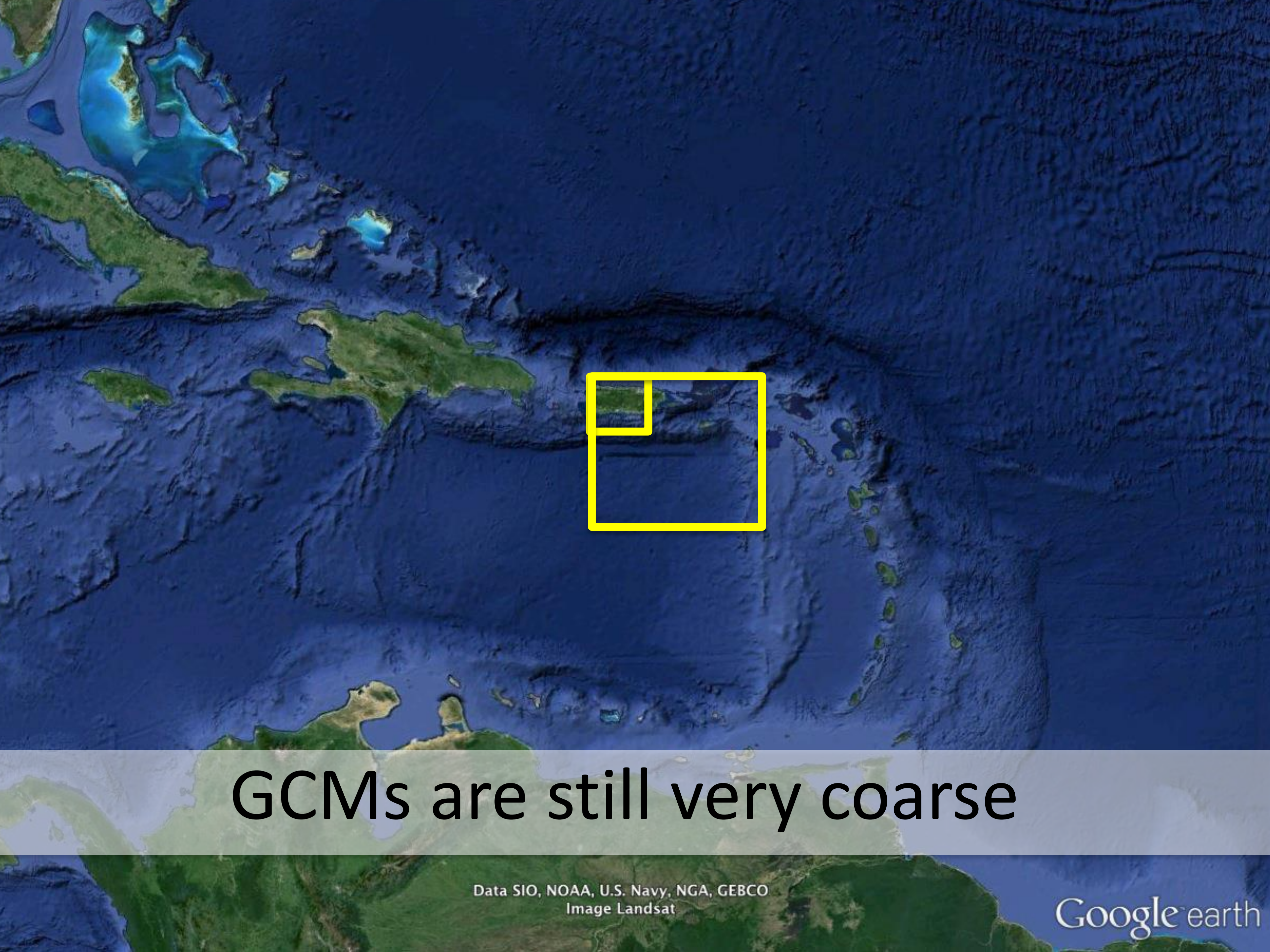


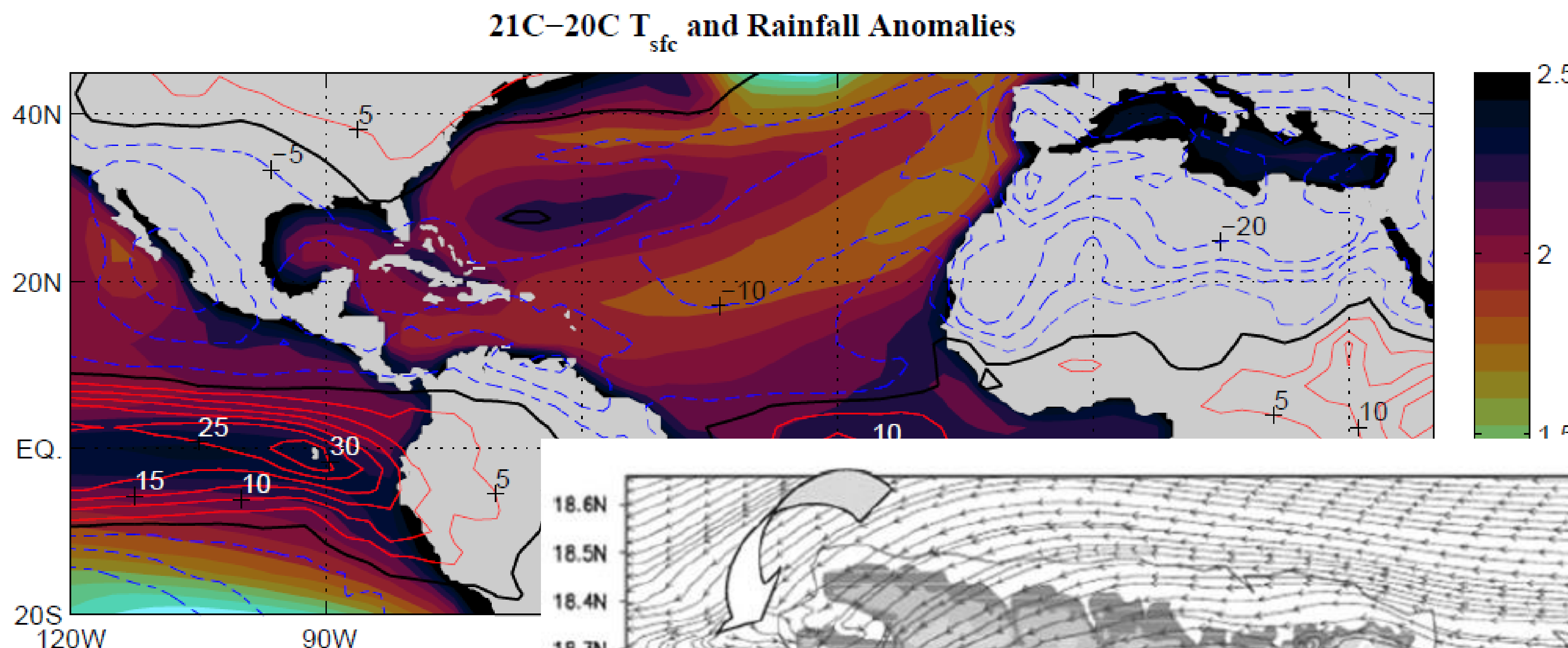
We need high resolution projections needed for Puerto Rico

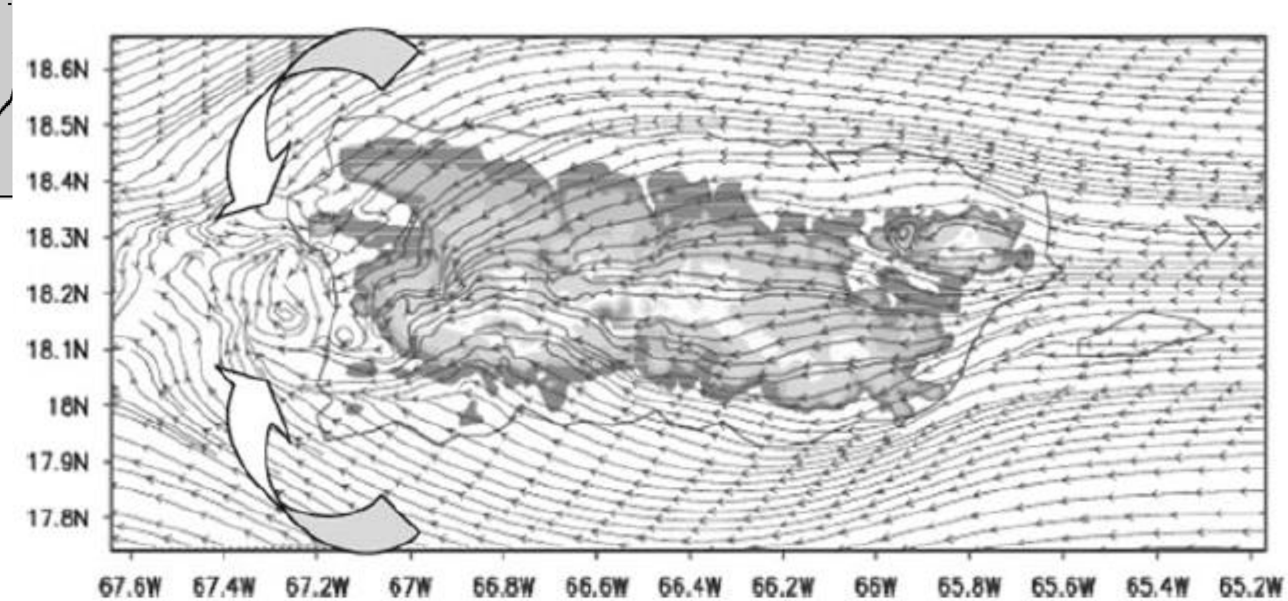
WHY?



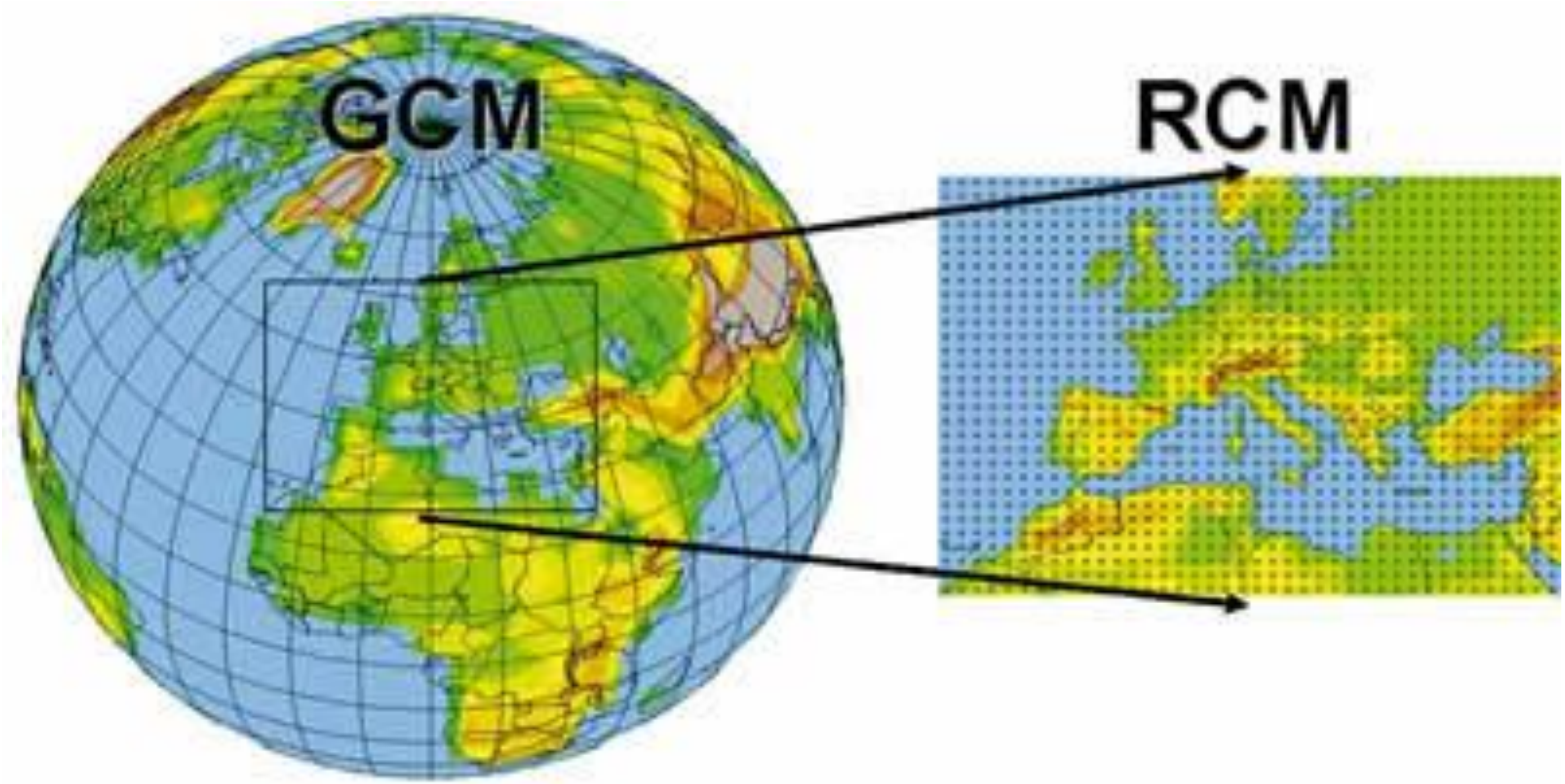
Jury et al. 2009, Boundary Layer Met.


GCMs are still very coarse
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Google earth





Local and regional features will mediate the larger global and regional response to increasing CO_2



Use 'Downscaling' to simulate or predict local climate processes that GCMs cannot resolve

Source: WMO

Downscaling Climate Projections

Simulating sub-grid-scale climate based on output from global models

By developing a statistical relationship between local climate variables and global model predictors

By explicit solving of process-based physical dynamics of the regional climate system

STATISTICAL DOWNSCALING

PROS: flexible, rapid, larger ensemble size

CONS: dependent on AOGCM performance and stability of large-to-small-scale forcing over decadal time scales

DYNAMIC DOWNSCALING

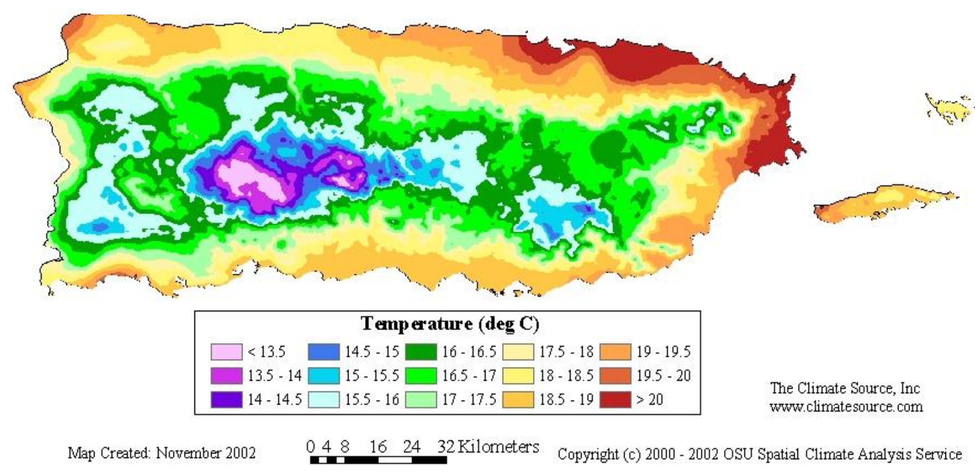
PROS: improve on AOGCM simulations by simulating sub-grid-scale processes; includes dynamical changes in response to large scale forcing

CONS: expensive & time consuming,
small ensemble size

Why dynamical downscaling over Puerto Rico?

High-resolution needed to capture the effects of complex topography and micro-climates over the island.

Observations – January Climatology



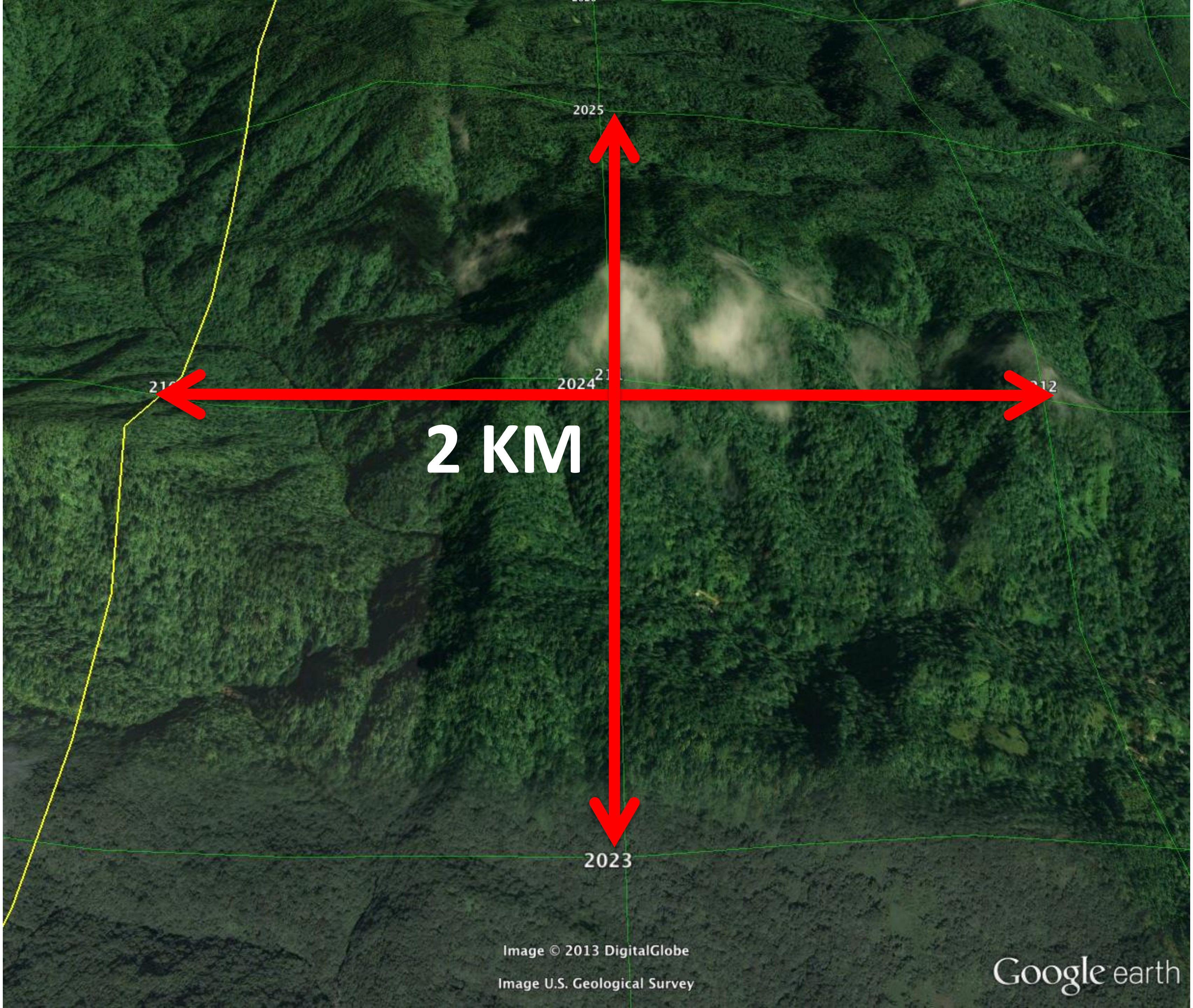
Many More Physical Variables Available

- Surface
  - Rainfall, Temperature, Humidity, winds, soil moisture/temperature, runoff, evapotranspiration, pressure
- Above canopy
  - As above, plus others
  - Mixing height, vertical winds
- Radiation
  - Incoming, outgoing, diffuse, net, cloud fraction
- Diagnostic Variables
  - Height of cloud base,
  - Statistical : Heat Wave duration, extremes, percentiles, etc.

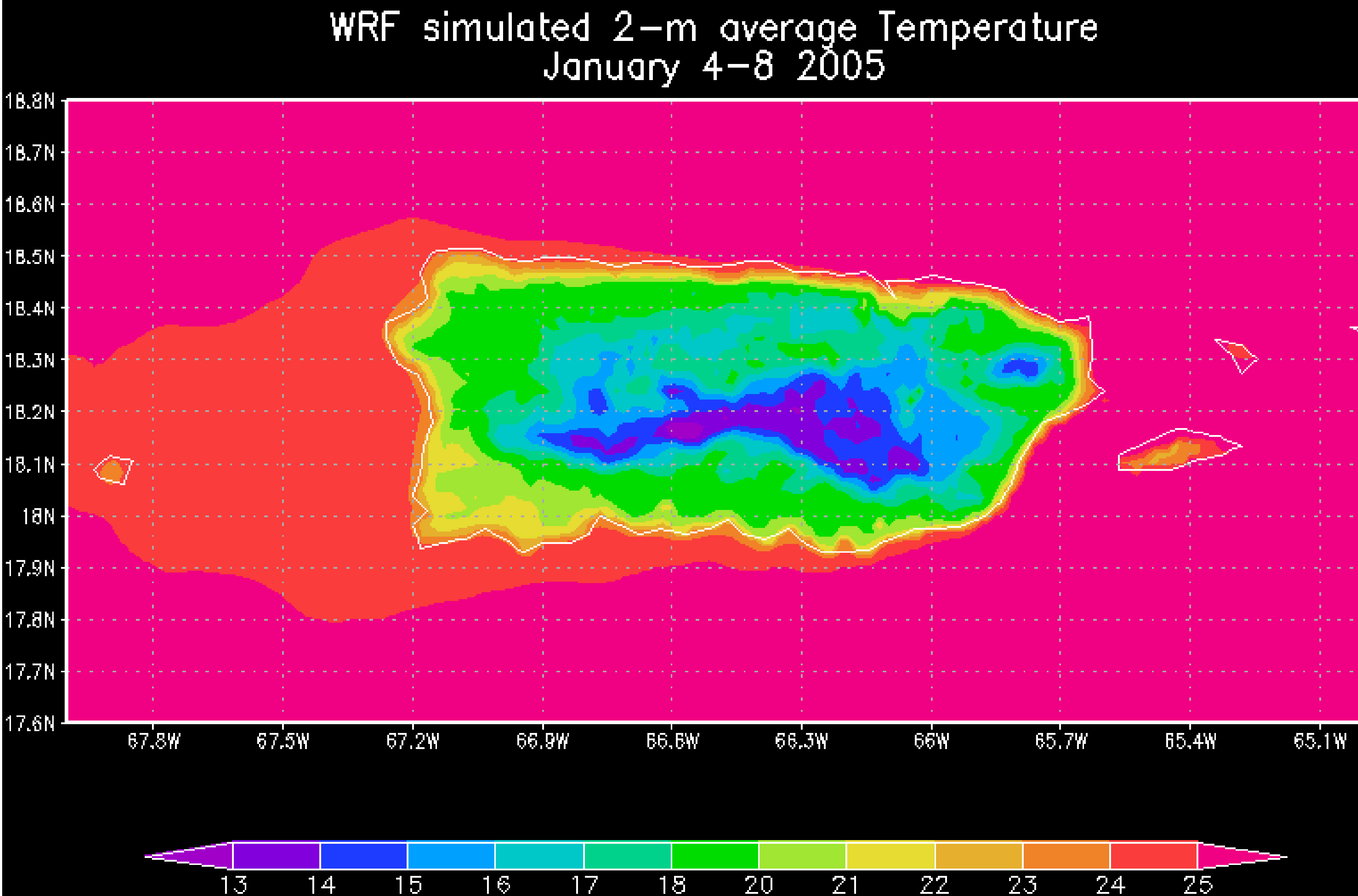
Stakeholder workshop to refine climate model output


2100
100 KM
700
800
900
2000
Resolving Terrain is critical
Data LDEO-Columbia, NSF, NOAA
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth


10 KM
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth


2025
2024
2023
2 KM
Image © 2013 DigitalGlobe
Image U.S. Geological Survey
Google earth

Sample of downscaling for 1 week



Incorporate Uncertainty into Study Design

GCM uncertainty

- Downscale at least two different GCMs
- GFDL & CCSM = decent mean climate and variability in the tropical Atlantic and Pacific

Incorporate Uncertainty into Study Design

Emission Scenario Uncertainty

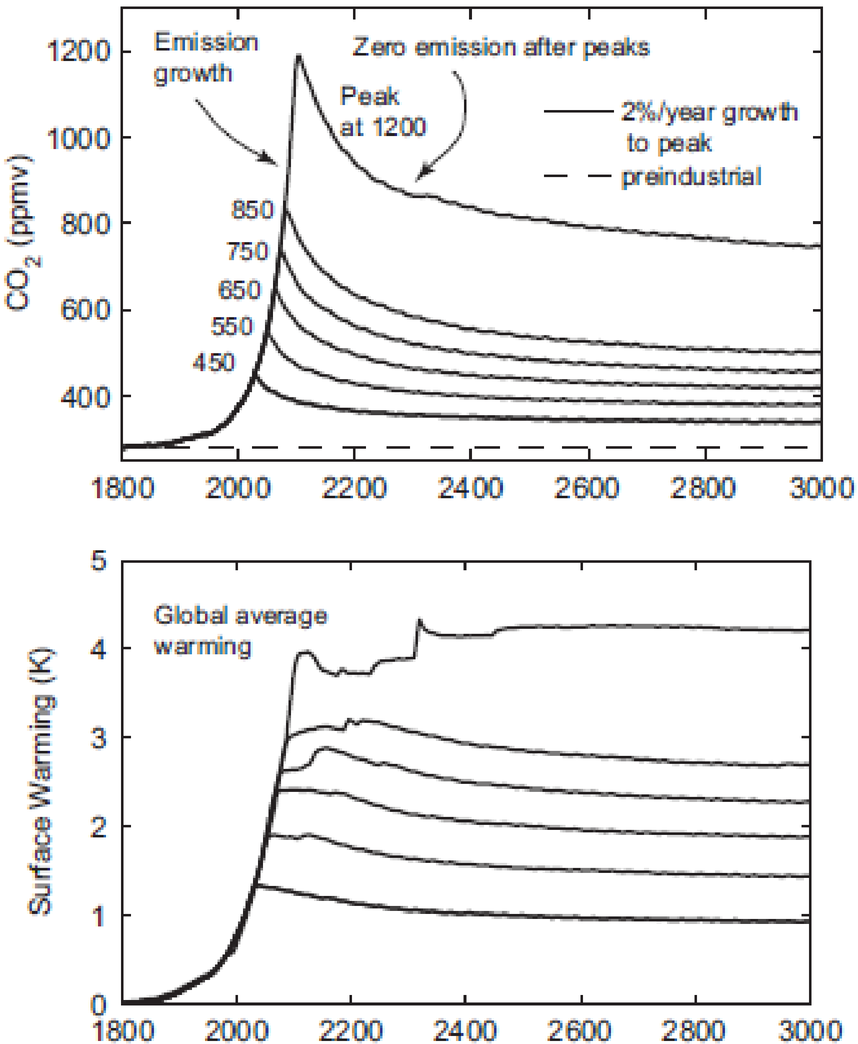
- Only use RCP 8.5, most aggressive fossil fuel emission scenario
- May include one more scenario if time and resources allow (RCP 2.6)

Incorporate Uncertainty into Study Design

Regional Climate Model uncertainty

– 20 year historical simulations
– 20 year future simulations (after 2040)
– 2 regional Models (WRF, RSM)

WHERE ARE WE HEADING?



Our actions now will have consequences for many centuries to come

WHERE ARE WE HEADING?

Actionable science can help us achieve our objectives through decision-relevant predictions

THANKS!