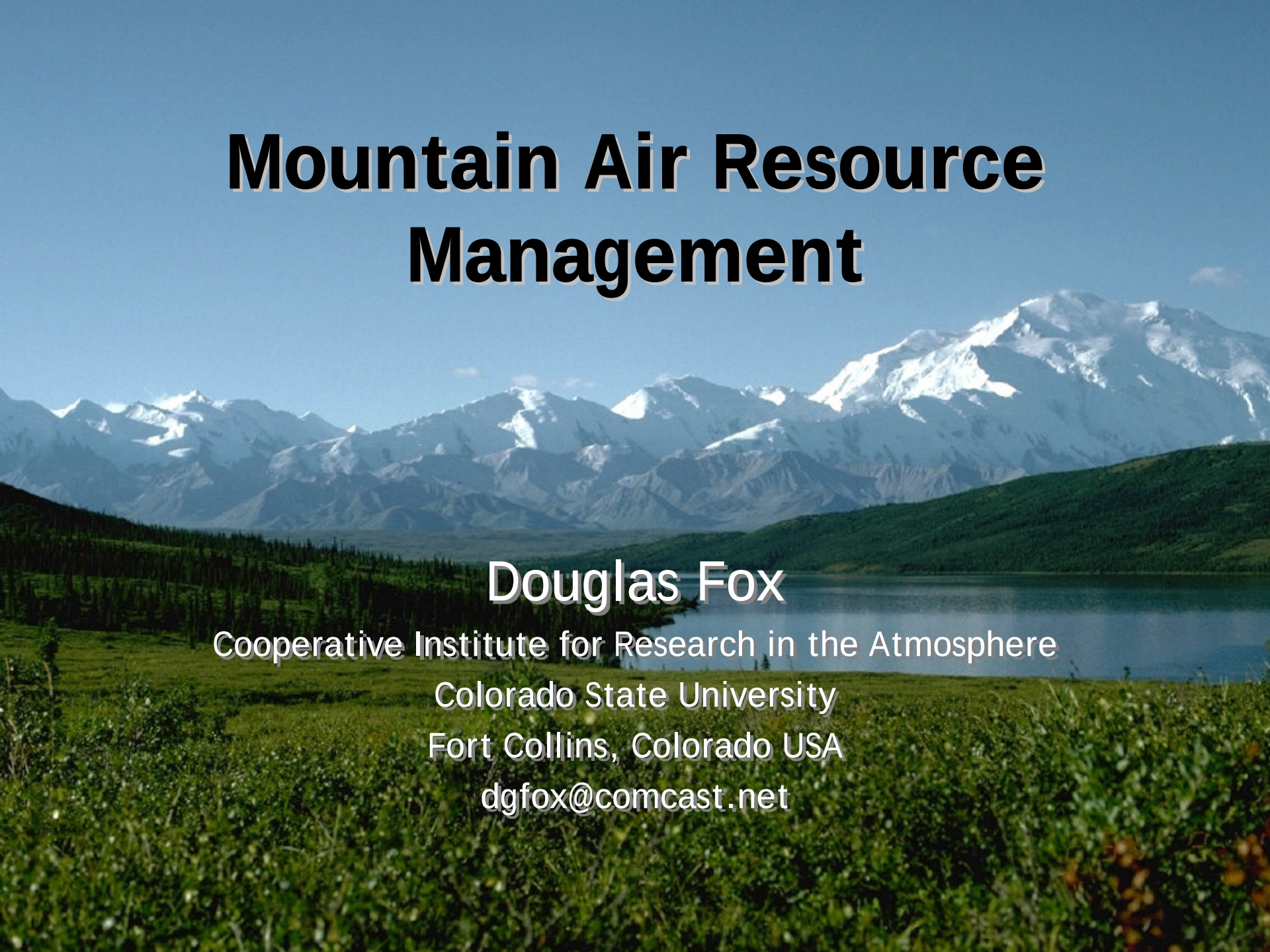

Mountain Air Resource Management

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Climate Change and Air Pollution: Mountain Air Resource Management

- Introduction & overview
- Managing mountain air resources:
  - The US Clean Air Act
- Science: Data & Tools
- Relevance to you ?

My background & perspectives:

- US government (NOAA, EPA & FS)
    - Air resource management
    - Climate Change program manager
- Colorado State University
    - Western US air quality research
- IPCC WG II 2nd Assessment (1994)
    - Lead Author Mountain Impacts
- Resident of the Isle of Man since 1999.

QuickTime™ and a decompressor are needed to see this picture.

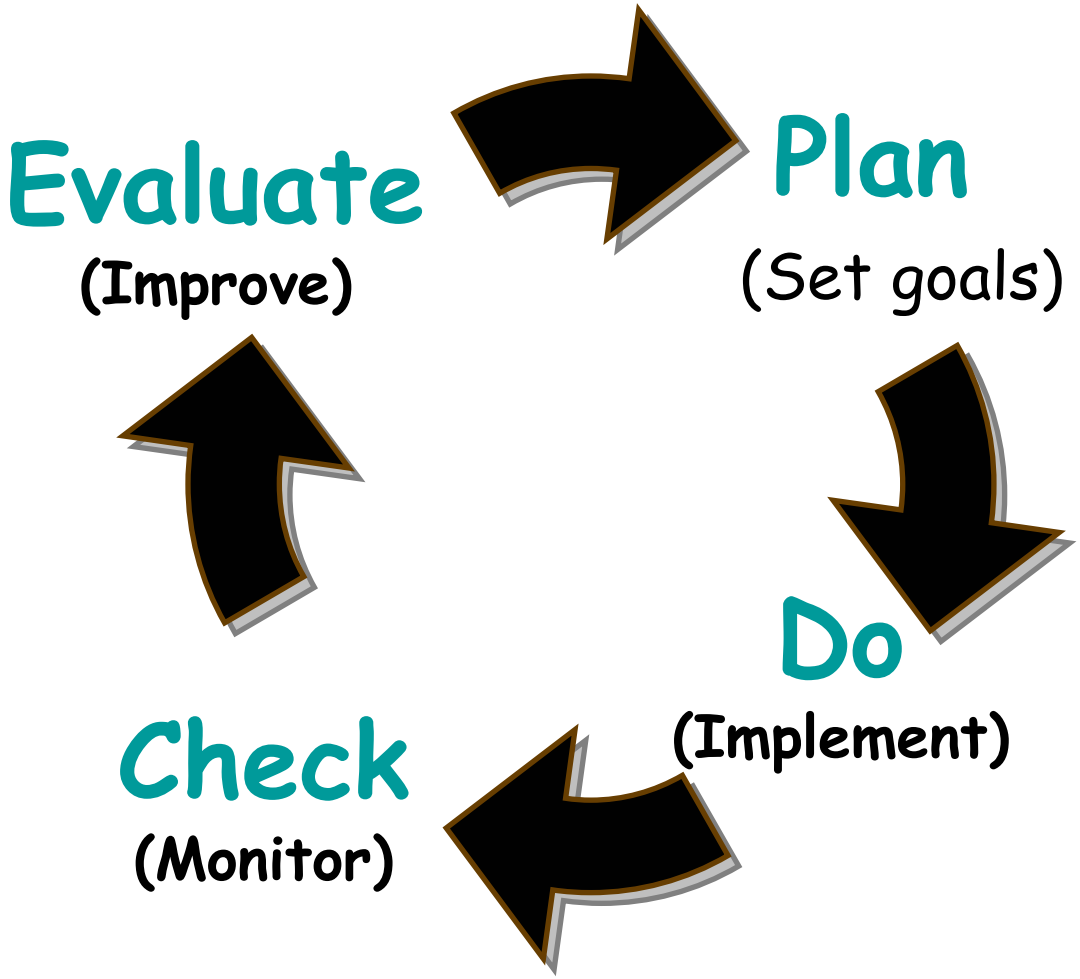
Introduction & overview

- Air Resource Management: concepts
- Climate change adaptation strategies:
  - US mountain land manager strategies;
  - Value of Parks & wilderness.
- External versus internal stresses on mountain regions;
- Relationship between air pollution and climate, especially climate change.
- Air pollution stresses:
  - what are they?
  - how do they impact mountains?

Air Resource Management

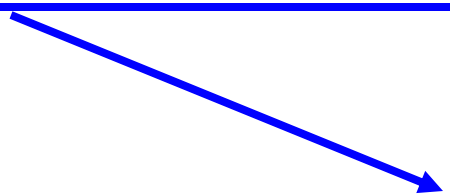
- **Air is a resource**:
  - Clean air is a limited but renewable resource.
  - Like soil & water it is an ecosystem component.
- **Land manager air resource management** involves:
  - Adapting to climate change
  - Minimizing air quality related stresses on landscapes

General Environmental Management System



Can we adapt to climate change ?

Changed magnitude & frequency



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Climate change adaptation strategies

- Active strategies for heavily managed landscapes:
  - Increase **resistance** to climate change impacts,
  - Create **resilience** to ongoing changes and climate-related disturbances,
  - **Respond** to climate influences.
- Passive strategies for more natural landscapes:
  - Increase wilderness
  - Reduce other external stresses

Active adaptation strategies

- Protect key ecosystem features & facilitate dispersal
- Reduce anthropogenic stressors:
  - Prevent invasives;
  - Reduce pollution
- Increase genetic & habitat diversity
- Protect replicate populations
- Restoration with natives post-disturbance
- ID / protect refugia for at-risk species
- Assist species migrations
- Examples: Increase Buffers & TES Pop Sizes, Stock Seed Banks, Intensive Reforestation to keep Habitat types, Landscape connectivity
- From MTNCLIM 2008 June 2008, Silverton, Colorado

Adaptation strategies for climate change in forest ecosystems of the western U.S.

MTNCLIM 2008 June 2008, Silverton, Colorado

Jessica E. Halofsky[1], David L. Peterson[1], and Kathy A. O'Halloran[2]

1 Pacific Wildland Fire Sciences Laboratory, Seattle, WA Seattle, WA

2 Olympic National Forest, Olympia, WA

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npressor
see this picture.

Hypotheses about ecosystem change in the West

- Increasing moisture limits will alter (tree and other) species composition and productivity by:
  - locally favoring more xeric species.
  - exacerbating episodes of vegetation dieback.
  - altering mortality and turnover rates. .
- **Disturbance will be the principal agent of ecosystem change**
  - Late 20th-century trends such as increasing insect mortality or fire area burned may be replaced by more abrupt changes.
  - Disturbance interactions produce complex nonlinear behavior, operate at multiple scales, and may be constrained by physical limits.

Climate change, fire, insects, and disturbance interactions: adaptation challenges in the West Don McKenzie Pacific Wildland Fire Sciences Lab U.S. Forest Service & UW Climate Impacts Group

Mixed conifer (Sierra Nevada, S. Calif)

- Multiple stressors:
  - Air pollution reduces vigor
  - Fire exclusion -> high stand densities
  - Extended warm & dry periods ->insects
- Cause:
  - Ponderosa pine, Jeffrey pine, white fir dieback
  - Fuels accumulate & dry out
- Resulting in severe fires & increases in exotic species where fires do occur.

Actively managing for climate adaptation

- Influence of changing climate must be considered in conjunction with every resource management activity planned and executed.
- Accessible adaptation options include ***reducing current stressors such as insects, fire, air pollution.***
- Because climate will continue to change, promoting resilience as a management strategy may only be effective until thresholds of resilience are overcome.
- Most importantly, the onset and continuance of climate change over the next century requires NF managers to think differently about ecosystems.
- Preparing for and adapting to climate change is as much a cultural and intellectual challenge as it is an ecological one.

Passive adaptation strategies

- Active strategies for heavily managed land:

- Passive strategies for more natural landscapes:
  - natural ecosystems with minimal barriers to migration, and sparse human populations provide opportunities for ecosystems to adapt to changing climates.
  - such strategies apply to wilderness & National Parks
    - US Clean Air Act provides tools to reduce stresses from air pollution.

IPCC Working Group II: adaptation strategies (2007)

- **"*Expansion of reserve systems*** can potentially reduce the vulnerability of ecosystems to climate change.... Ultimately, adaptation possibilities are determined by the conservation priorities of each reserve and by the magnitude and nature of the change in climate."
- A primary adaptation strategy to climate change and even current climate variability is to ***reduce and manage the other stresses on species and ecosystems***, such as habitat fragmentation and destruction, over-exploitation, eutrophication, desertification and acidification [and tourism].....
- "..... it may be possible to preserve many alpine species in ***managed gardens*** at high elevation since many mountain plants are likely to survive higher temperatures if they are not faced with competition from other plants....

Reasons for reserves

As we watch the sun go down, evening after evening, through the smog across the poisoned waters of our native earth, we must ask ourselves seriously whether we really wish some future universal historian on another planet to say about us: "With all their genius and with all their skill, they ran out of foresight and air and food and water and ideas," or, "They went on playing politics until their world collapsed around them."

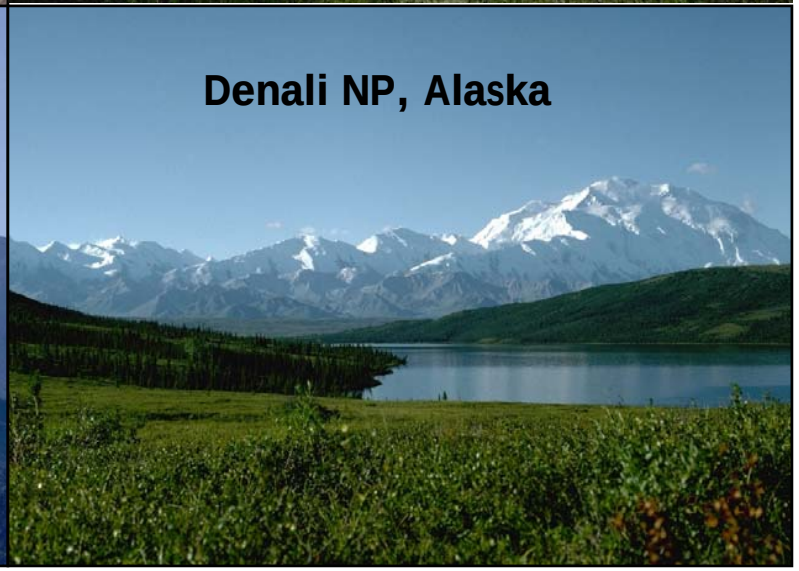
-- U Thant *(Burmese diplomat and the 3rd Secretary-General of the United Nations)*

US wilderness example

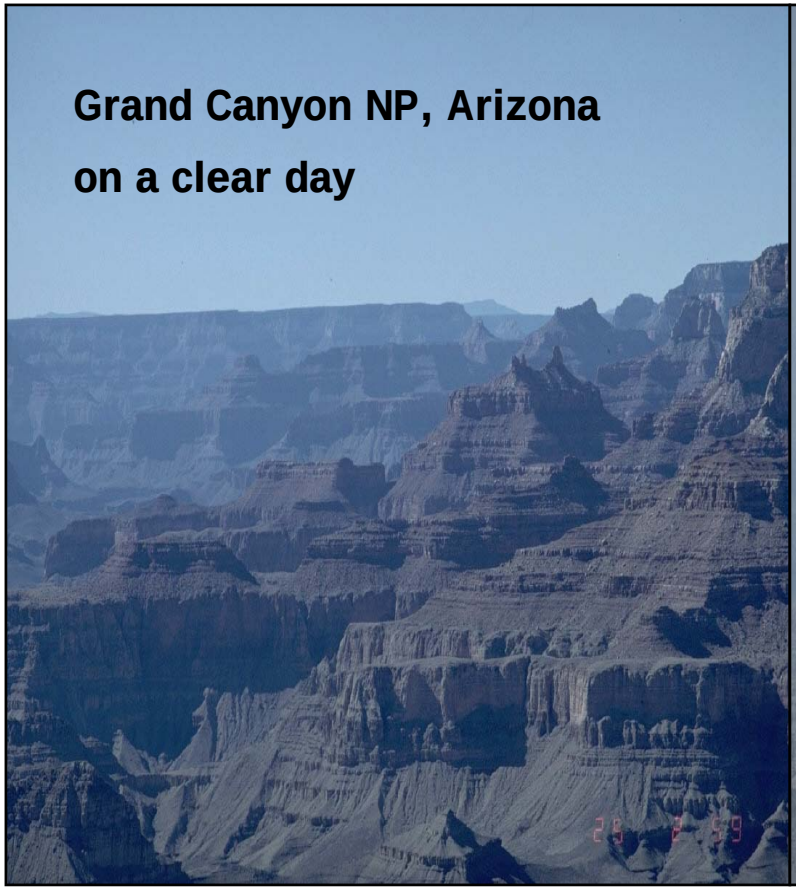
- Wilderness Act (US) in 1964 established a national wilderness preservation system.
- “A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain….”
- Formally defined as ”…an area of undeveloped Federal land retaining its primeval character and influence without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions . . . ."
- Currently there are 359,228 square kilometers in 703 separate areas preserved in the US ~4% of US total land area.
- Preservation minimizes human intervention but allows certain “permitted” activities, grazing, mining, non-motorized recreation.

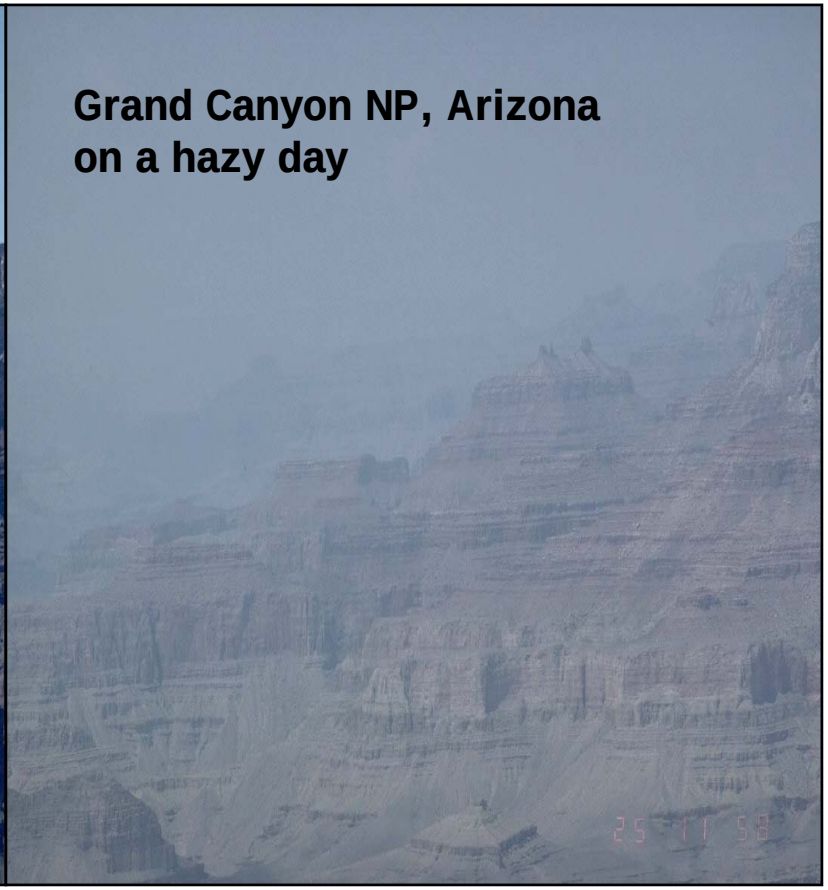
Wilderness and public lands

Some of the wilderness areas



Importance of air quality & visibility

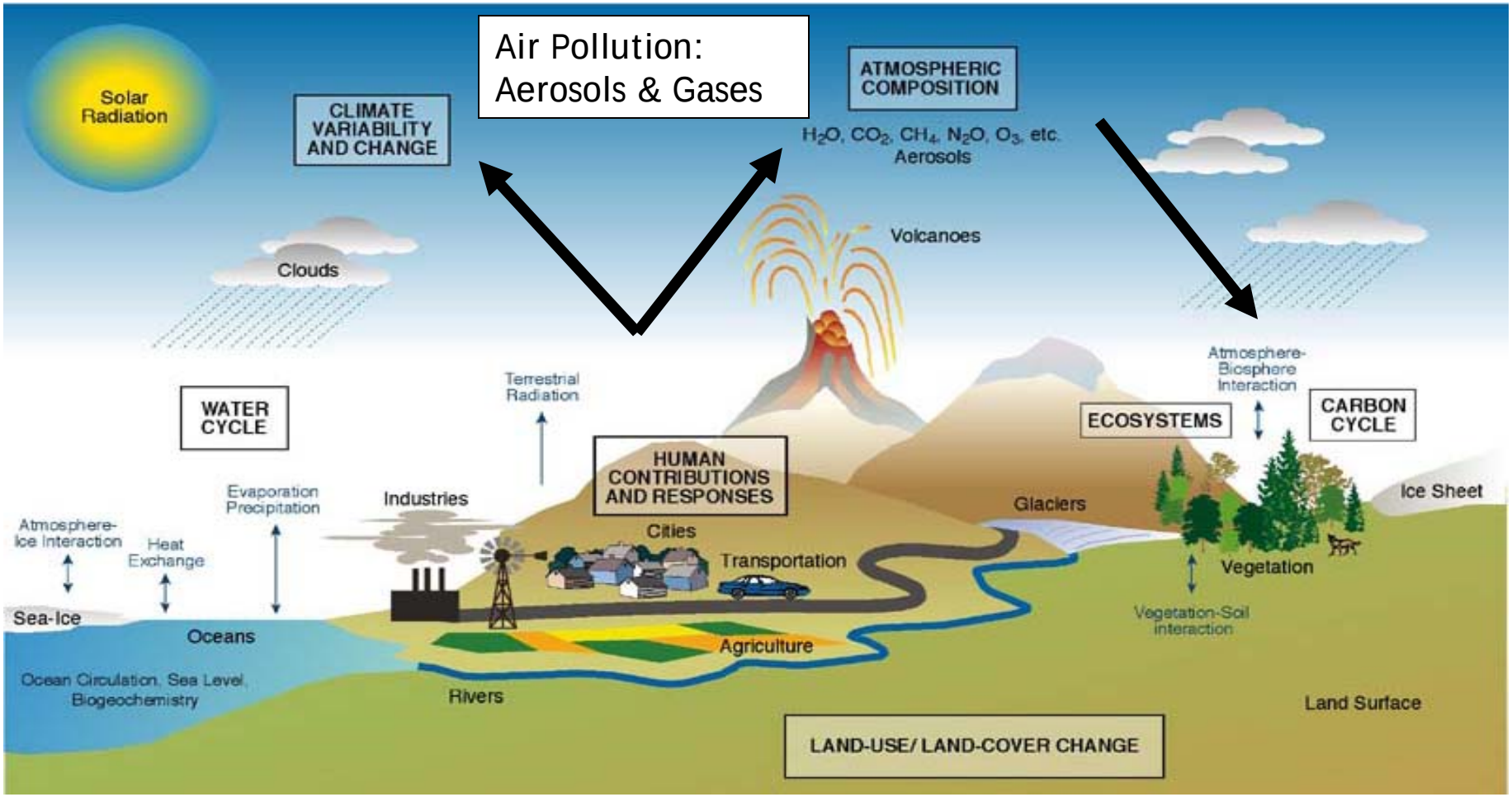


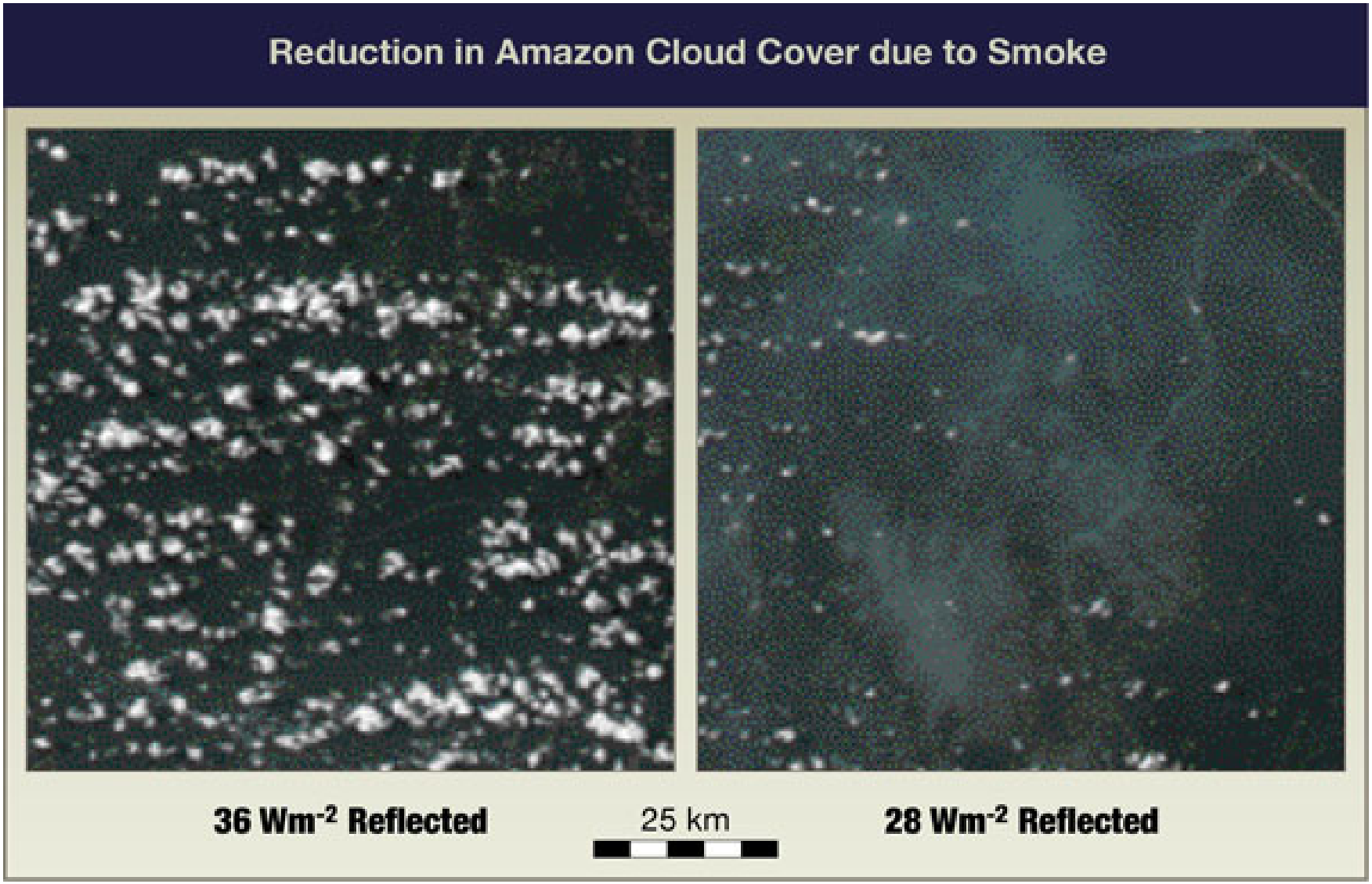


External versus internal stresses on mountain regions

- Internal stresses
  - Human activities
    - Agriculture, grazing & communities
    - Tourism
  - Economic exploitation (mineral extraction)
- External stresses
  - Climate
  - Air pollution
    - Atmospheric deposition

Relationship between air pollution and climate





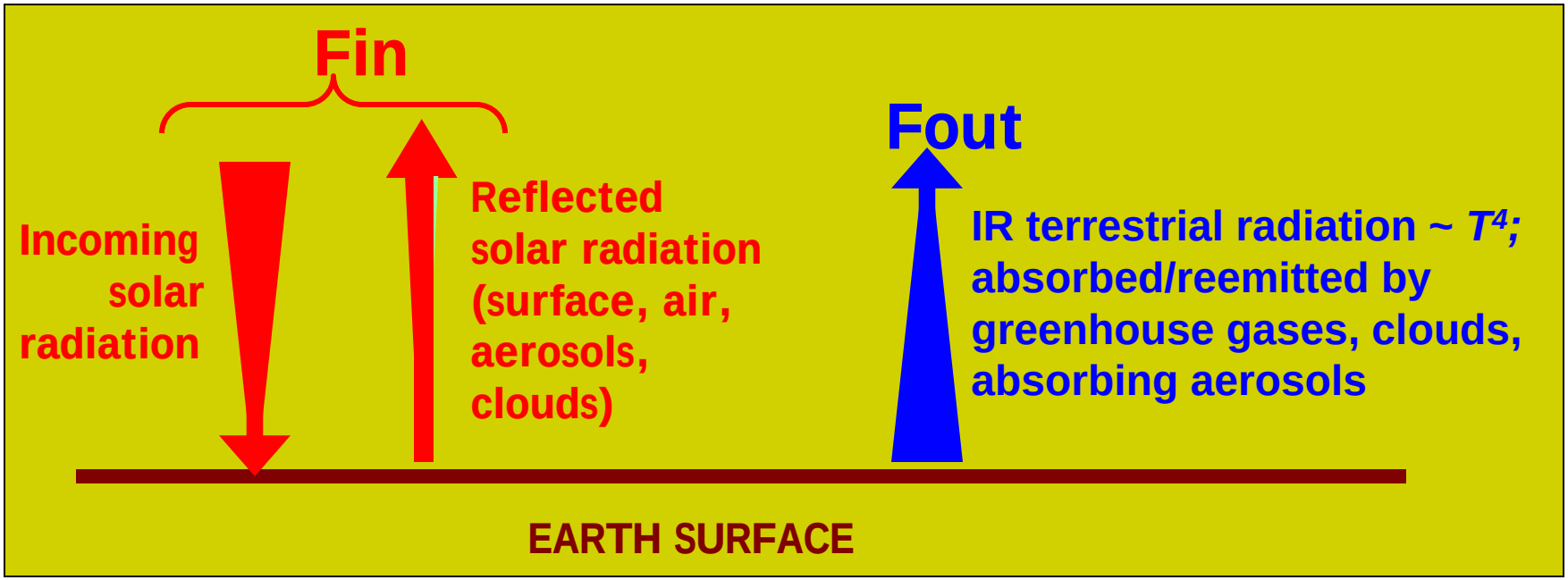
Aerosols can have both a warming and cooling influence on global climate through a variety of diverse regional effects.

Credit: R. Simmon, J. Allen, and Y. Kaufman, NASA/Goddard Space Flight Center.

Relationship between air pollution and climate change

- Air pollution impacts on climate change:
  - Tropospheric ozone (heating)
  - Aerosols (direct & indirect)
    - Sulfate/nitrate (cooling)
    - Carbonaceous aerosol
      - Black carbon (heating)
      - Organic carbon (cooling)
- Climate impacts on air pollution:
  - Temperature/ozone correlation
  - Temperature/soa relationships
  - Circulation & Precip pattern changes

RADIATIVE FORCING OF CLIMATE CHANGE

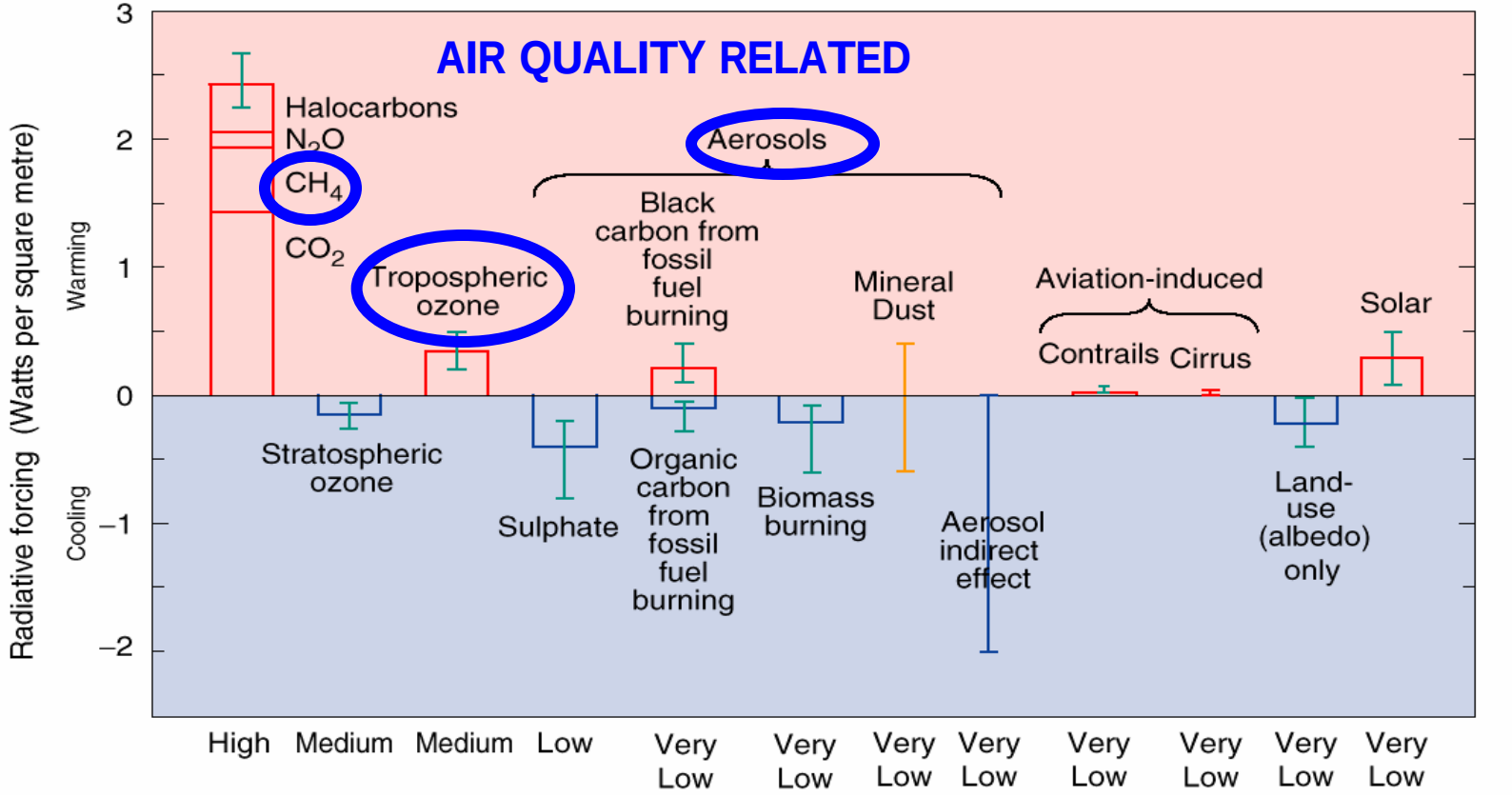


climate is defined by radiative equilibrium: $F_{in} = F_{out}$

- **Instantaneous perturbation Radiative forcing** $\Delta F = F_{in} - F_{out}$**;**
  - **Greenhouse gases** $\Delta F > 0$ **(warming)**
  - **Absorbing aerosols** $\Delta F > 0$ **(warming)**
  - **Scattering aerosols** $\Delta F < 0$ **(cooling)**

General circulation models (GCMs) give $\lambda = \Delta T_o / \Delta F = 0.3\text{-}1.4$ **K m^2 W^{-1}**

GLOBAL RADIATIVE FORCING OF CLIMATE, 1750-present [IPCC, 2001]



AQ-related greenhouse forcing: 0.48 (CH_4) + 0.35 (O_3) + 0.2 (BC) = 1.03 W m^{-2}
…compare to 1.46 W m^{-2} for radiative forcing by CO_2

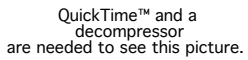
Also note -0.50 W m^{-2} forcing from sulfate and OC aerosols; SO_2 emission reductions result in positive radiative forcing

Air pollution stresses

- Ambient air quality
  - Ozone direct damage to vegetation.
- Deposition
  - Sulfate & nitrate dry & wet deposition
    - Acidification
    - Other N effects
      - Fertilization
      - Eurtophication
- Visibility

Air pollution stresses

This animation illustrates the nitrogen cycle, from emission sources through to ecosystem impacts..



Atmospheric Pollution: Mountains & Global Change

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