Designing the Climate Observing Systems of the Future

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Global Reference Upper Air Network, April 25, 2016

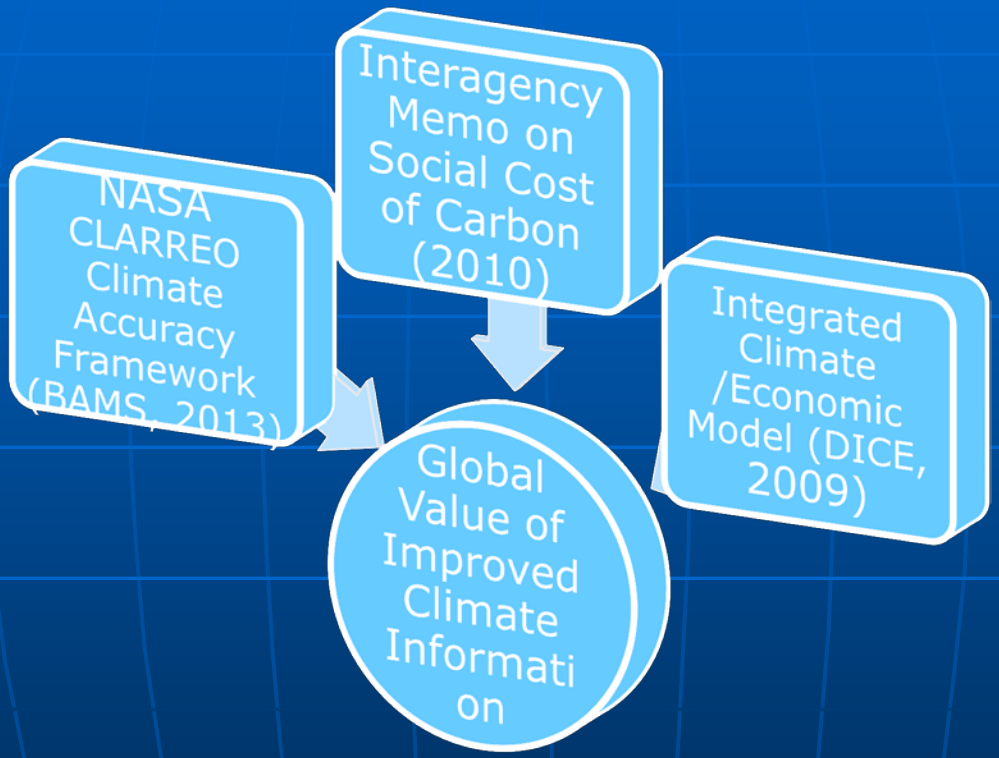
The Problem

- Many climate observing systems are inadequate to address climate science needs.
- Some systems are in a state of decline.
- Limited resources for investment.
- Some past investments have under-delivered.

The Approach – to date

- Analyze current investment strategies for climate observations;
- Discuss research questions with highest priorities for climate observations;
- Identify methods for assuring investments are appropriate for addressing the science questions.

What is the right amount to invest in climate science?



Cooke et al., Journal of Environment, Systems, and Decisions, July 2013, paper has open and free distribution online: doi:10.1007/s10669-013-9451-8

VOI Estimation Method

BAU Emissions

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Climate Sensitivity

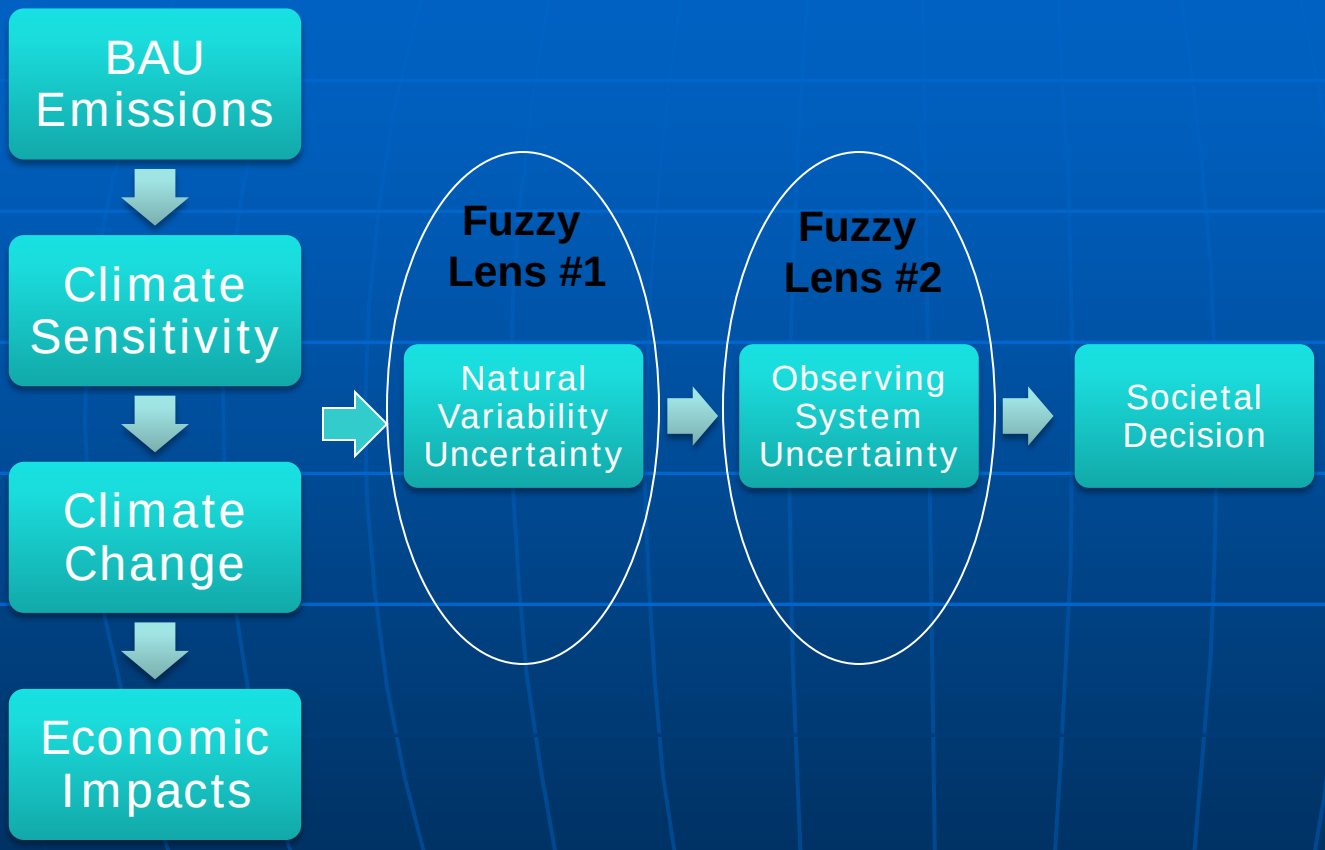
↓

Climate Change

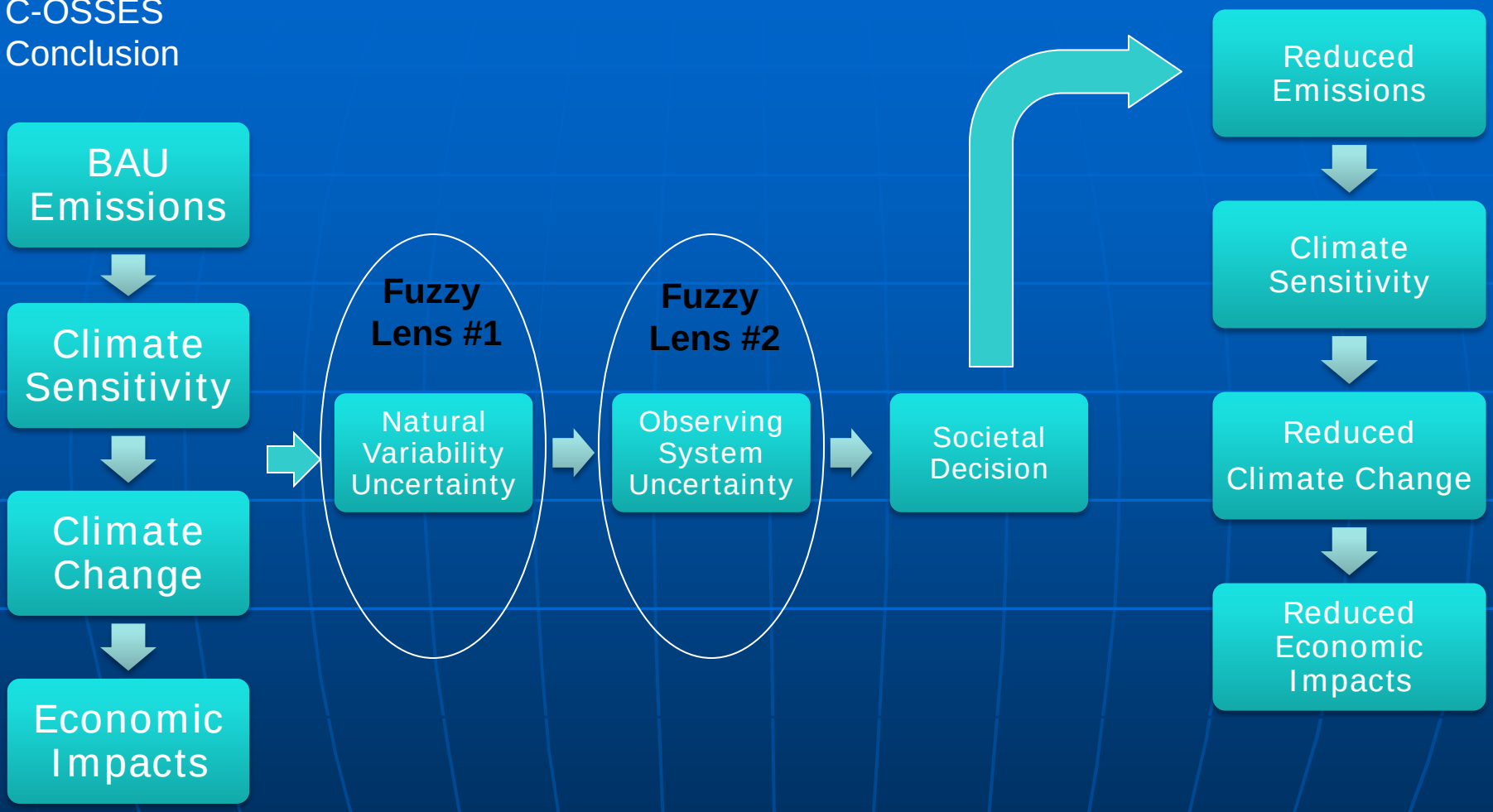
↓

Economic Impacts

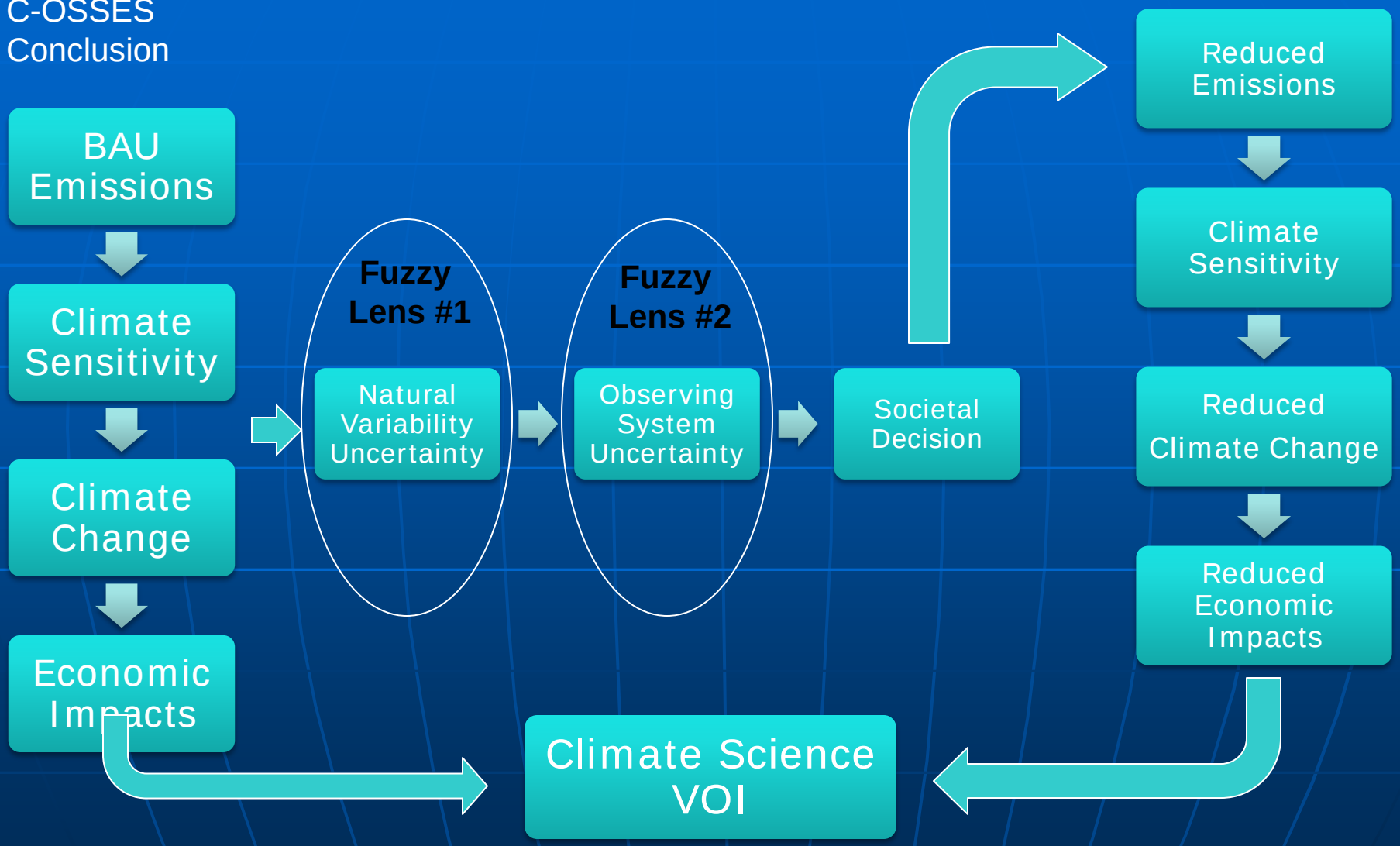
VOI Estimation Method



VOI Estimation Method



VOI Estimation Method



VOI vs. Discount Rate

Run 1000s of economic simulations and then average over the full IPCC distribution of possible climate sensitivity

Discount Rate	VOI (US 2015 dollars, net present value)
2.5%	$17.6 T
3%	$11.7 T
5%	$3.1 T

Advanced Climate Observing System:

Return on Investment: $50 per $1

Cost of Delay: $650B per year

Even at the highest discount rate, return on investment is very large

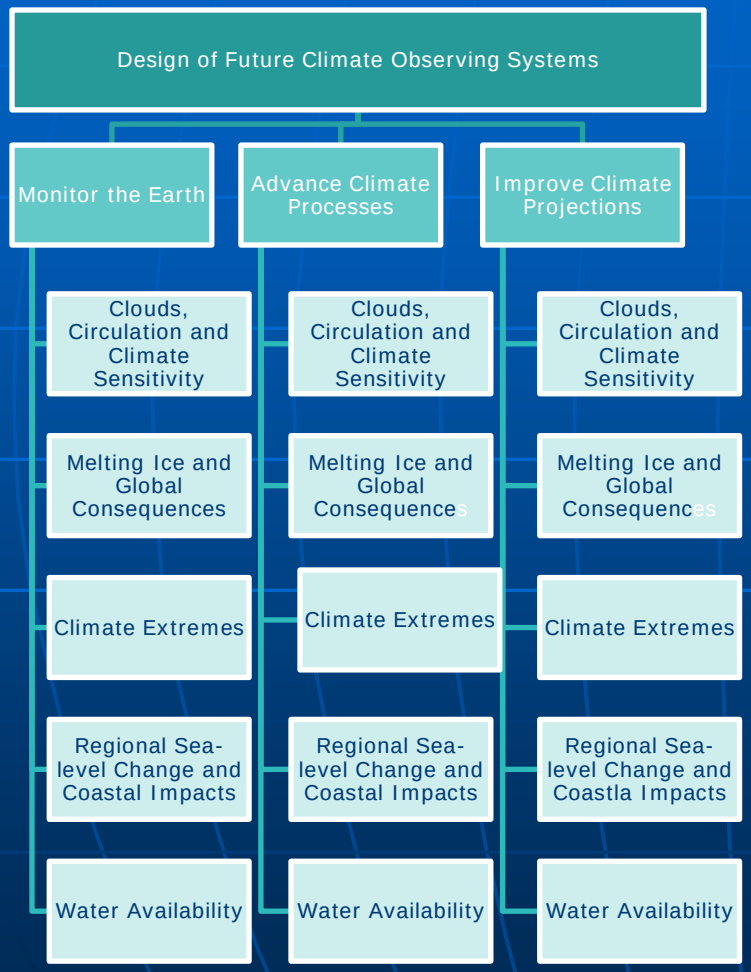
Analyze current investment strategies for climate observations

- To date, investment in climate observations has been considered as a part of general scientific investment.
- Similar to weather forecasts, there is a shift towards understanding that climate research and services are necessary for economic planning and infrastructure.
- Value of Information (VOI) research

Identifying Priorities

- Climate Services Priorities may be well addressed on a national basis.
- Research priorities require discussions among modelers, observationalists, meteorologists).
- To date, engagement has started with US entities: USGCRP, AGU, AMS, Decadal Survey, informal and formal discussions.
- Winners and losers—everyone has their pet project.
- Surprisingly strong, positive feedback.
- Sense of urgency and unity.

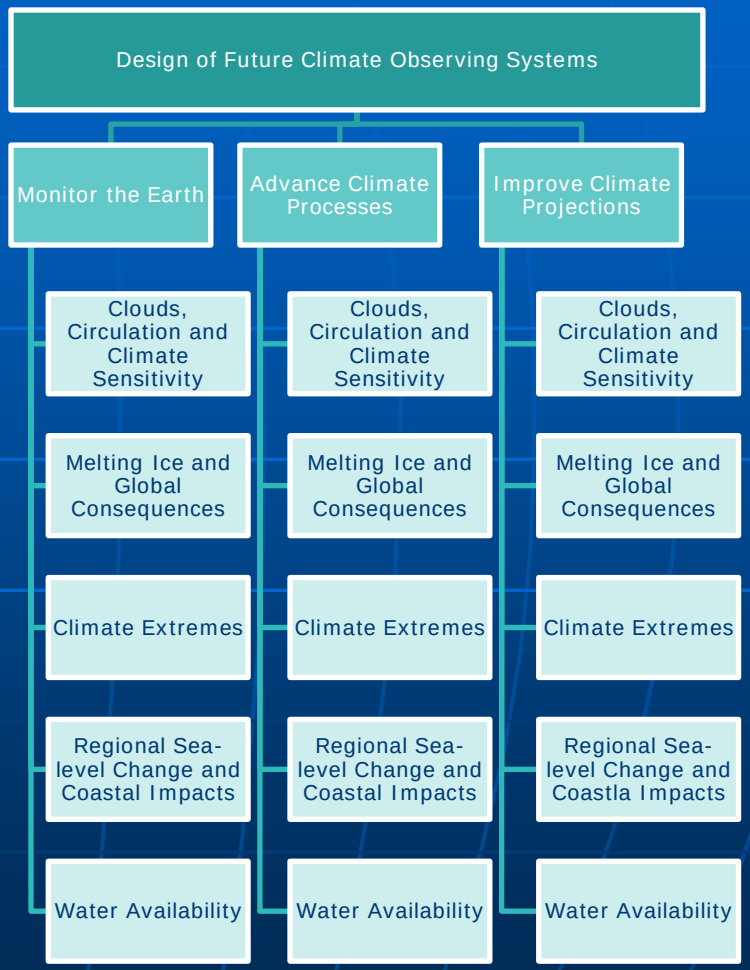
Addressing the World Climate Research Program's Grand Challenges



- We may have additional Grand Challenges.
- Each category is really a set of questions.
- GRUAN addresses key priorities for fundamental measurements in monitoring the Earth.
- GRUAN priorities are tied to all existing priorities.

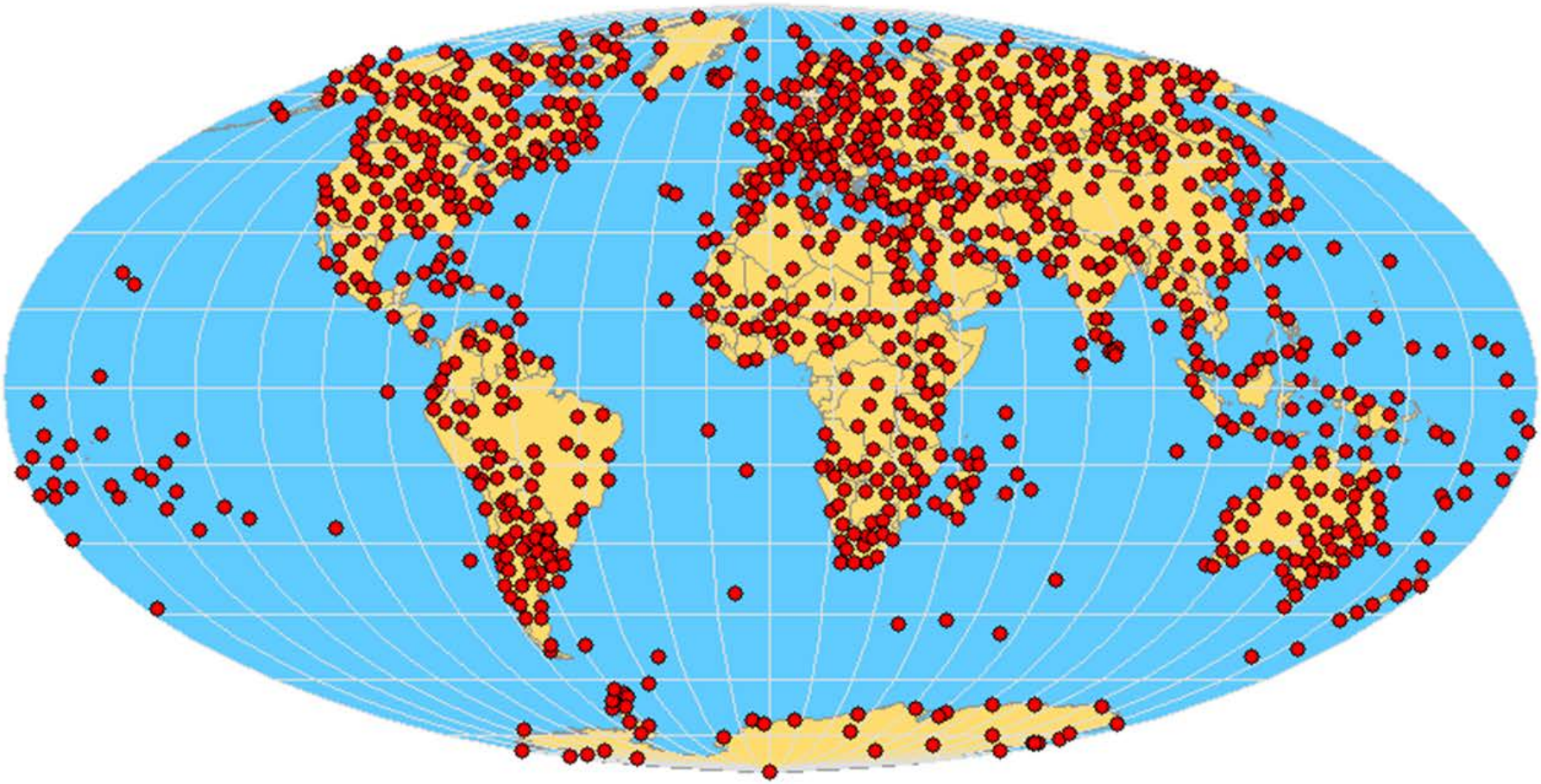
Mutual Support with GRUAN

- Evaluation of current observational capabilities
  - Across all platforms
  - Current and Future



GCOS Surface Network

(1017 Stations)



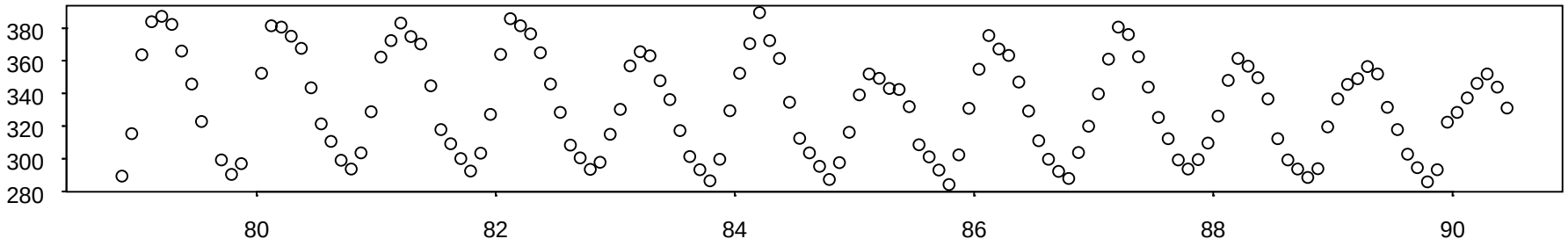
GCOS Secretariat, 1 March 2014

Climate Observation Simulation System Experiments

- We can simulate the value of proposed observing systems to their ability to address climate science needs.
- We can use natural variability on appropriate time scales to understand the power of a system to address a testable hypothesis.
- We can control four parameters in our observing systems:
  - What we measure
  - Where we measure
  - How frequently
  - How accurately
- Choices on all four of these issues affect our ability to effectively address scientific questions.

SBUV OZONE TOTAL COLUMN OZONE - 40N

Original Monthly Averaged Data



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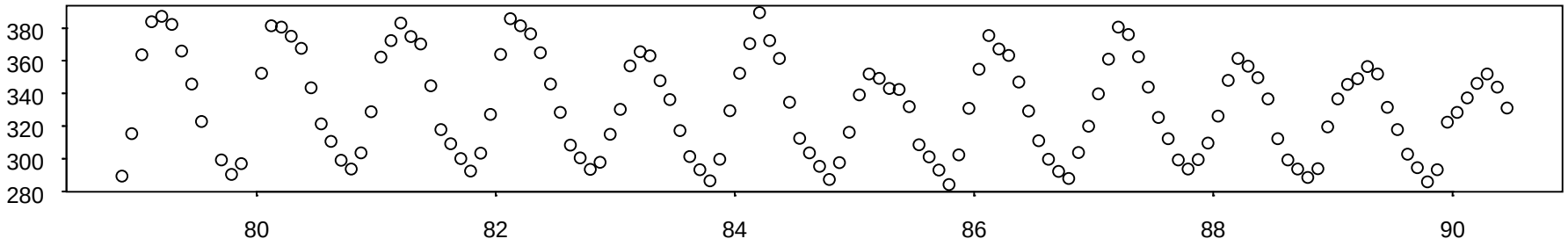
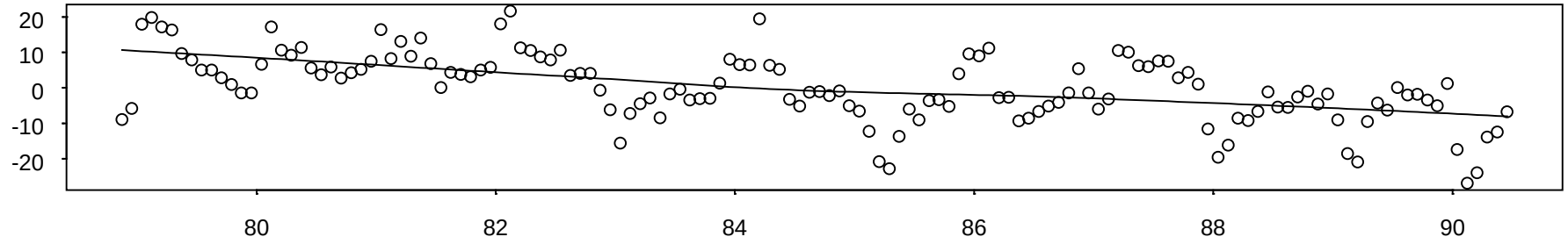


Monthly Means Removed, Lowess Line Fit Superimposed



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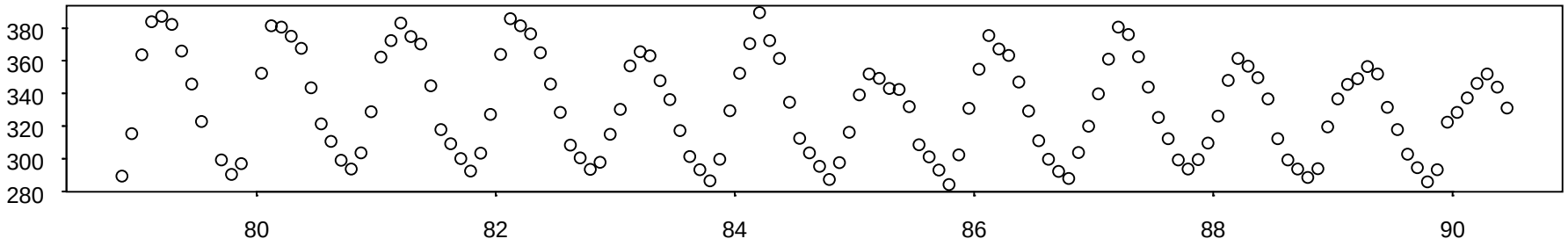

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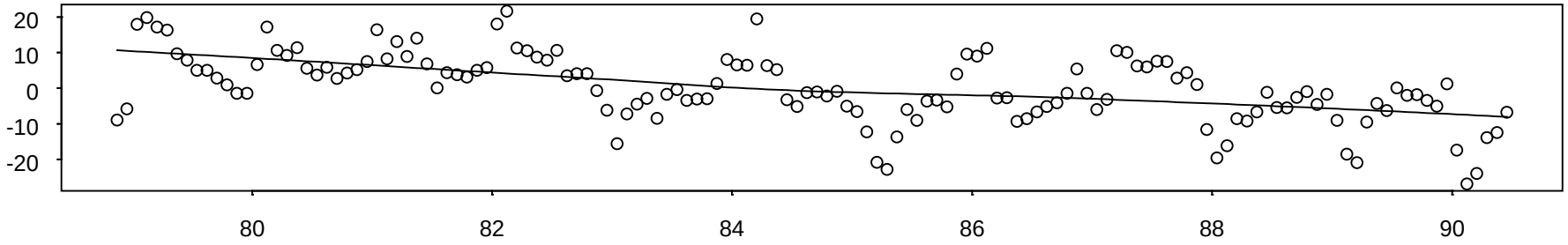
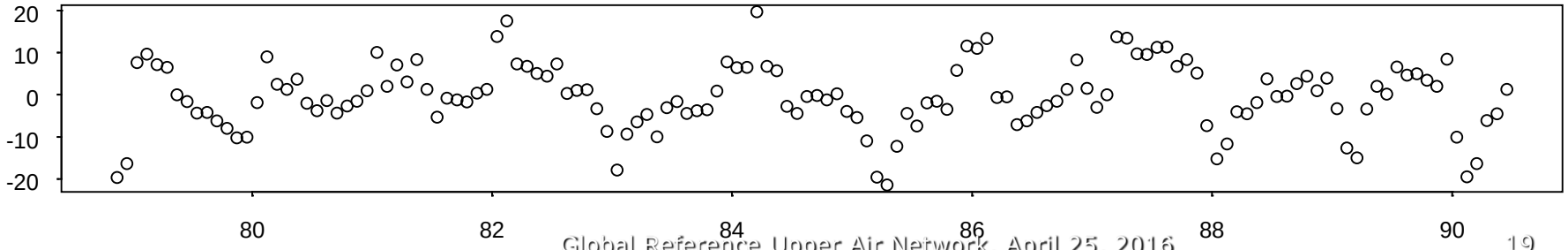
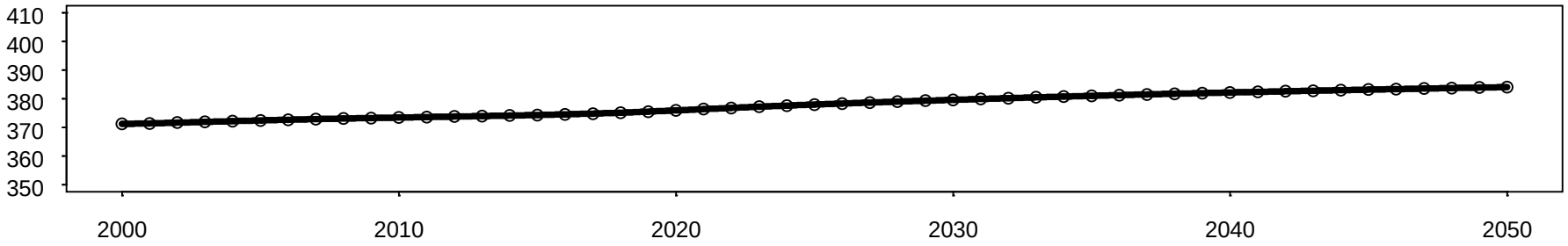


Residuals From Lowess Line Fit



GSFC 2d Predictions with SBUV Residuals of Total Col. Ozone (d.u.) 40N

GSFC Predictions - without climate change



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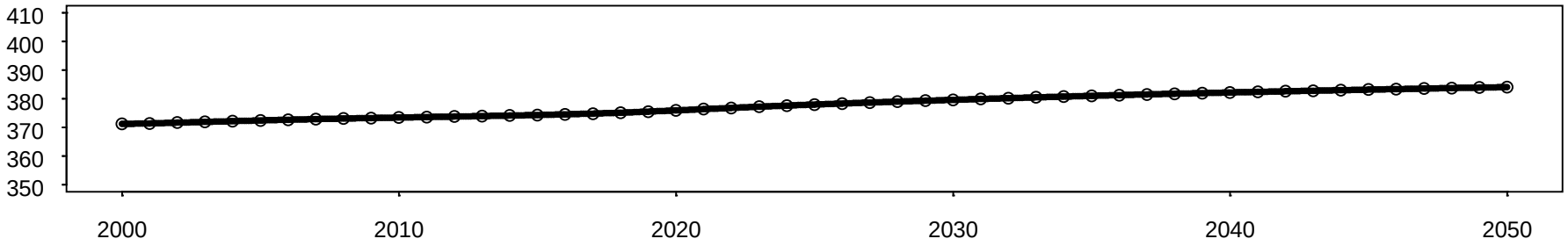
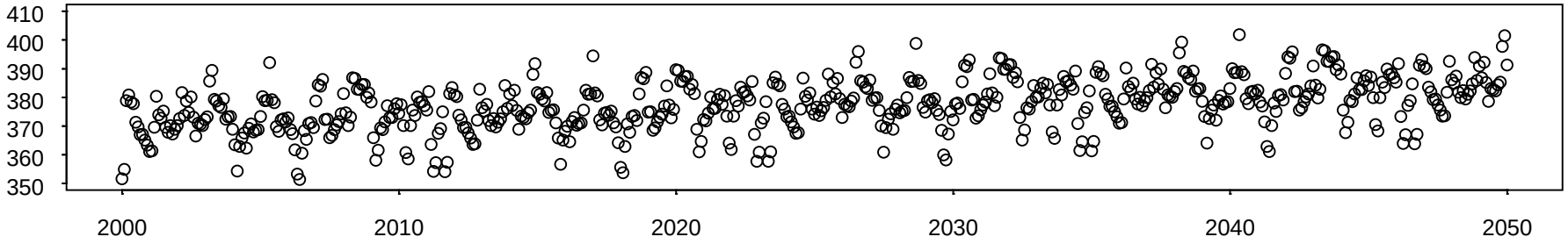


GSFC Predictions with SBUV Lowess Residuals



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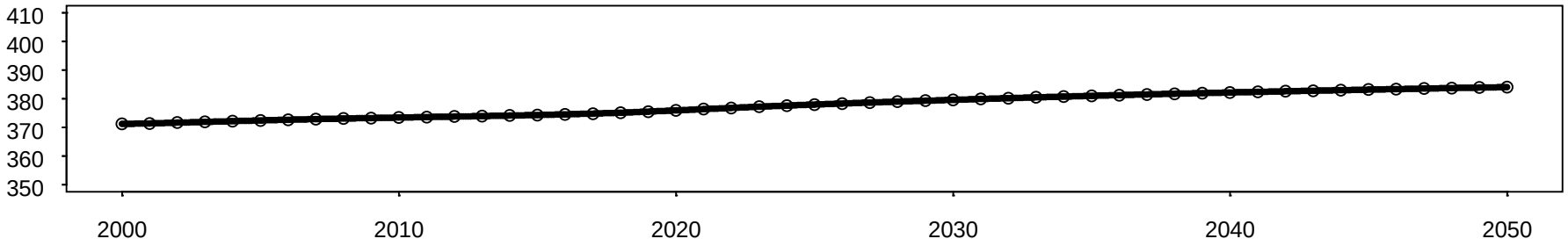
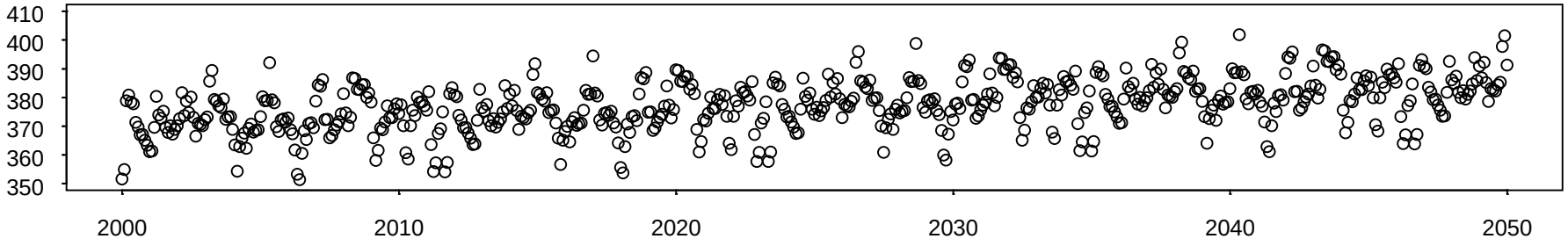
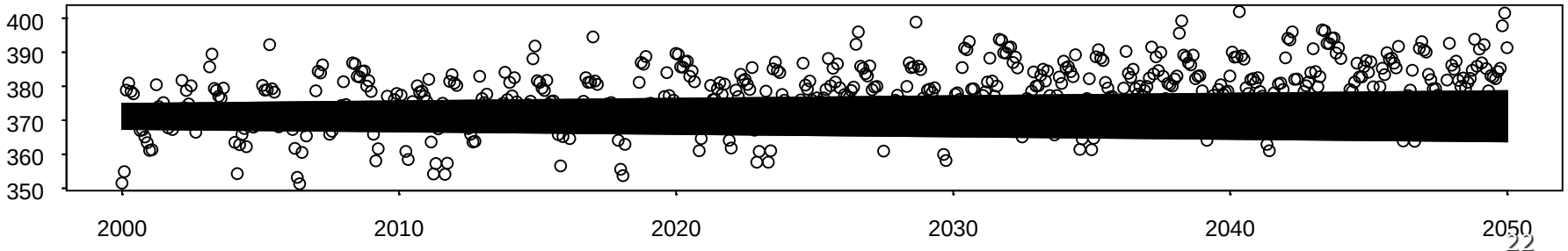


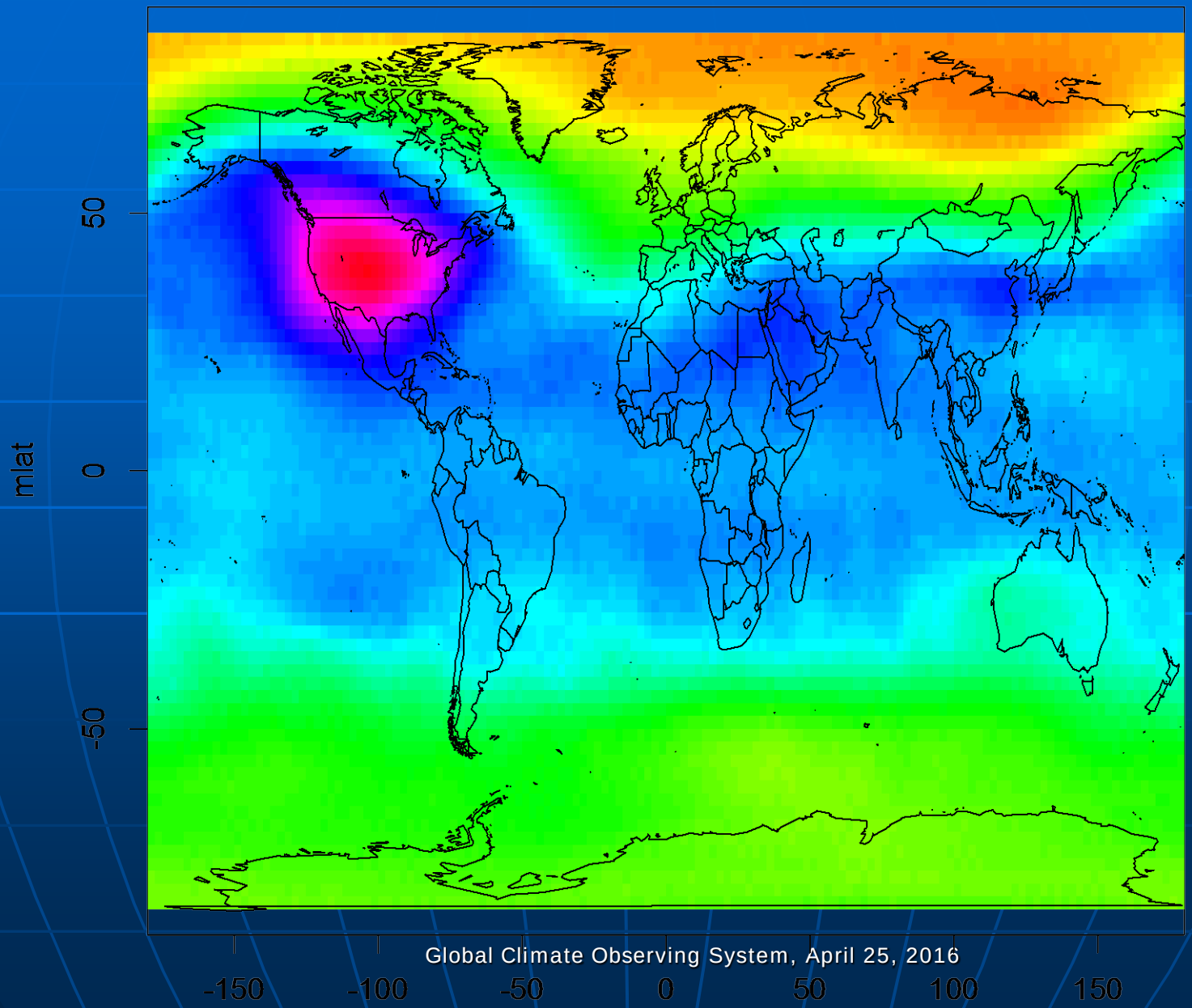
GSFC Predictions with SBUV Lowess Residuals



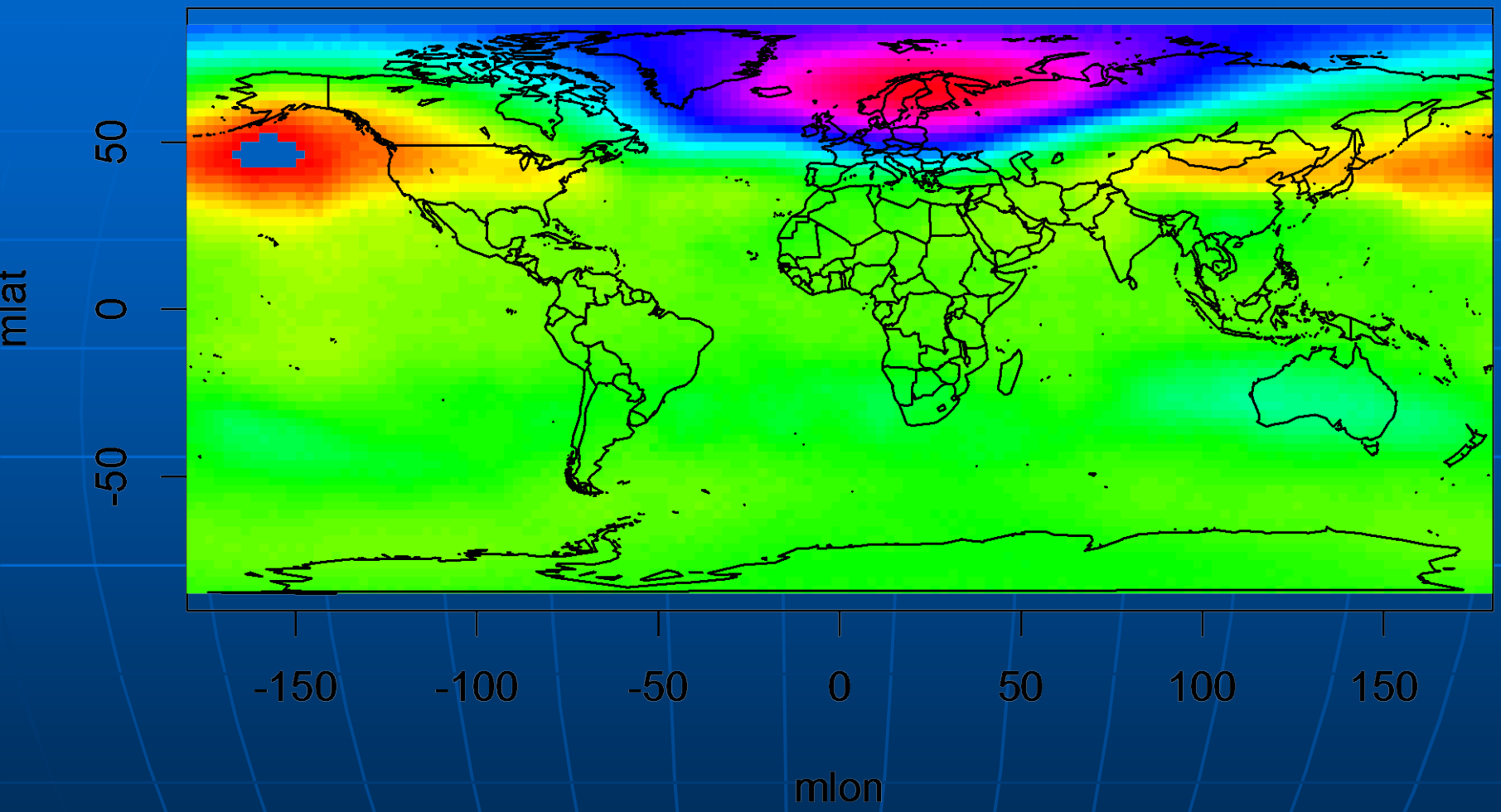
with +-1% error plus +-1% drift



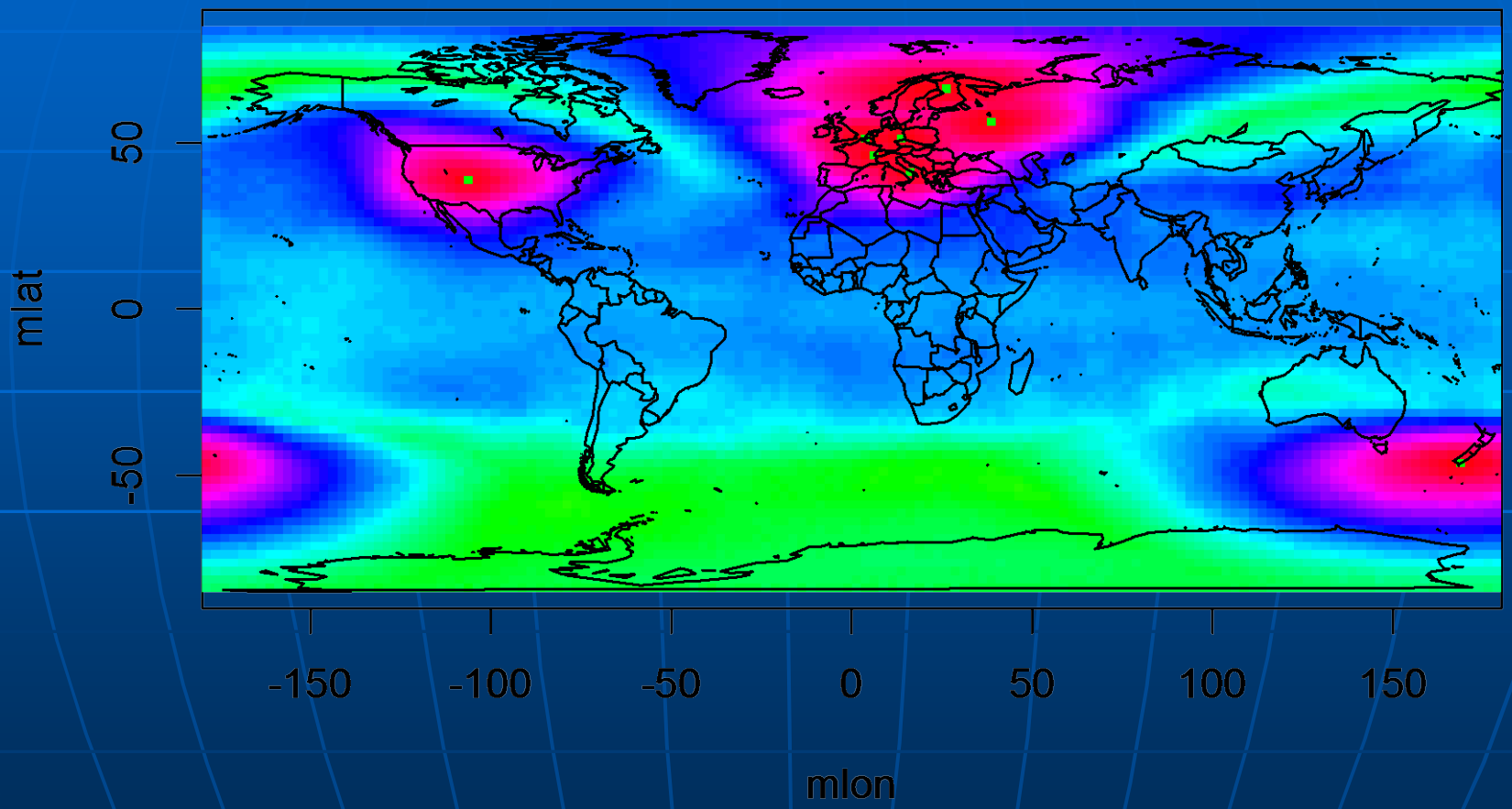
Correlation of Boulder in Lower Stratosphere



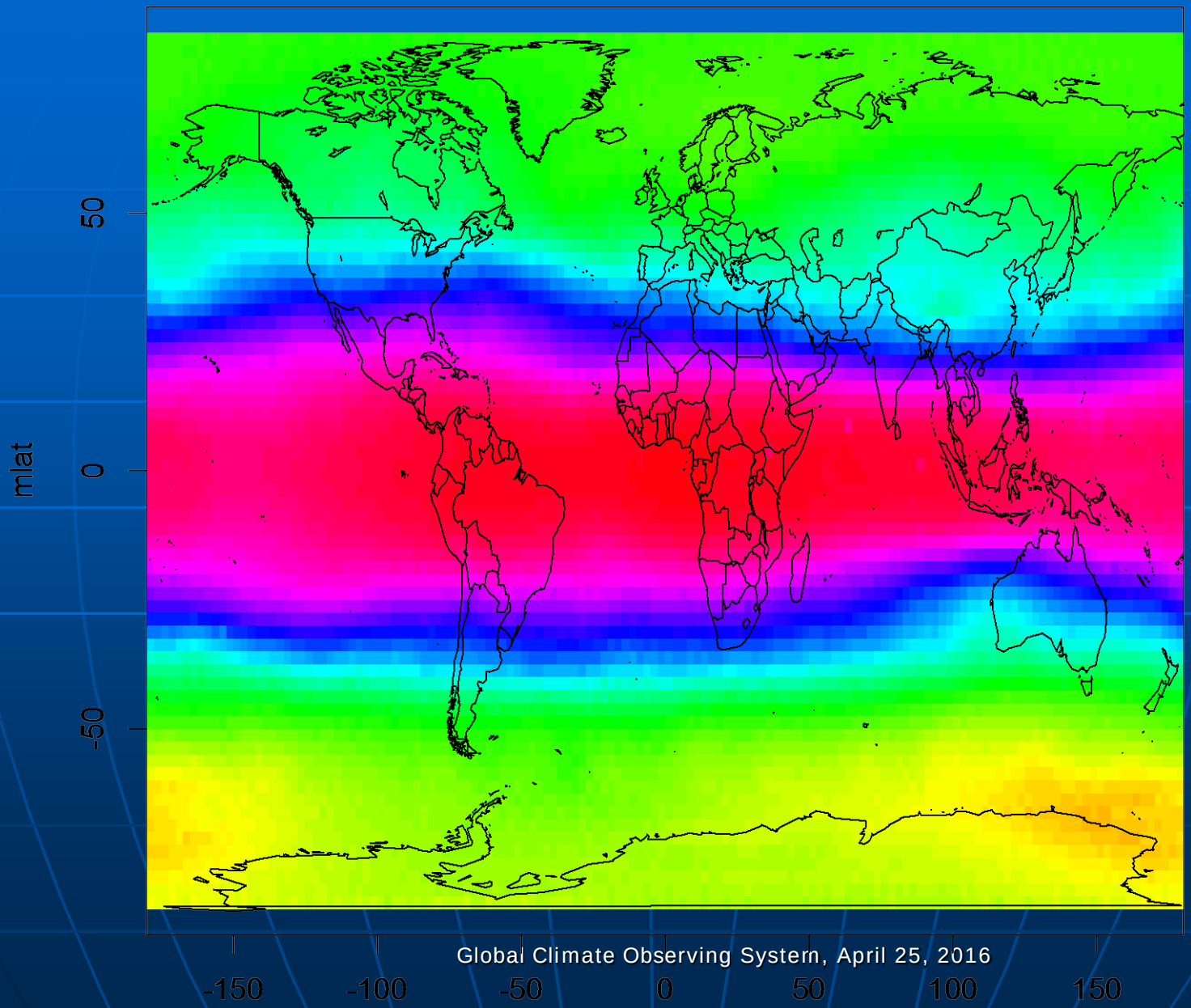
Correlation of Sodankyla in Lower Stratosphere

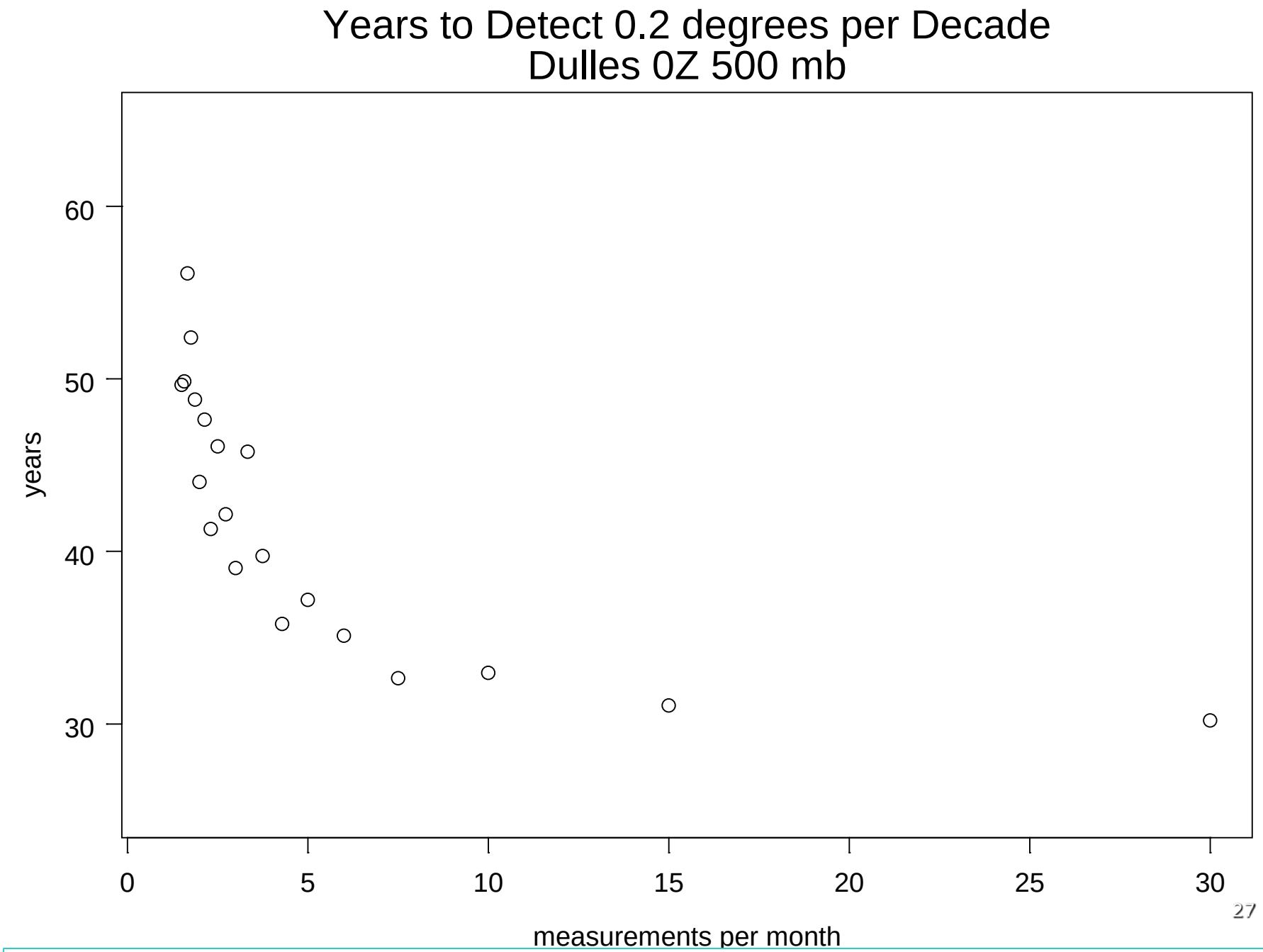


Maximum Correlation from eight GRUAN sites in Lower Stratosph



Correlation of 0 Lat/Lon in Lower Stratosphere




Years to Detect 0.2 degrees per Decade
Dulles 0Z 500 mb
years
60
50
40
30
0
5
10
15
20
25
30
measurements per month

Climate OSSEs

- Climate OSSEs can estimate success of proposed observing systems.
- What, where, when and how accurate can all be addressed in a climate OSSE.
  - Trend assessment
  - Process studies
  - Improved climate models
- Realistic variability and appropriate measurement uncertainty all need to be addressed objectively.
- Current ad hoc OSSEs can result in overpromising and wasted investments.

Conclusion

- We need to take an analytical approach to climate observations.
  - Amount of investment should be appropriate.
  - Climate priorities should be identified first.
  - Observation systems should be analyzed objectively.
- GRUAN is a critical component of future planning of climate observations.
- Now is the time.