What are the key uncertainties?

1. The Common Causes and Remarkability of Recent Changes in the Arctic System
2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes
3. Defining the Extreme States of the Arctic System
4. How to Produce Useful Scenarios of the Future
5. Sorting out the Interactions Between Global and Arctic Modes of Variability

1. The Common Causes and Remarkability of Recent Changes in the Arctic System

- how do we track these changes
- what unprecedented environmental changes are Arctic residents noticing that differ from the pattern of normal or natural variability that they have observed in the past
- what are the appropriate conceptual models
- how to link observations of change to their causes
- natural vs. anthropogenic
- how do we integrate across systems physics – HARC
- where and what to measure
- sensitivity and key variables
- mis-match between info we need and what models can predict

1. The Common Causes and Remarkability of Recent Changes in the Arctic System

What is the impact of this uncertainty on our understanding of the Arctic System?

- high (we see changes but not sure of which model to apply)

1. The Common Causes and Remarkability of Recent Changes in the Arctic System

What is our level of confidence in the above assessment?

- high

1. The Common Causes and Remarkability of Recent Changes in the Arctic System

What is our level of readiness to deal with this uncertainty?

- high in some areas and regions (Barents), but … don't have a theoretical understanding of the atmosphere-ocean circulation; insufficient long-term ecosystem time-series (Toolik Lake only ~25 years)

1. The Common Causes and Remarkability of Recent Changes in the Arctic System

Should this focus area be addressed by a new or existing initiative, by one or a combination of existing ARCSS components, or by some other means?

- yes – existing: SEARCH, LTOs/LTERs

2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes

- how do we model these things (non-linear)
- impacts on society
- how do these things re-organize or synchronize ecosystems and society
- what are the ecosystem buffers
- rates and reversibility of change
- the frequency of extreme events
- what is an extreme event
- are we looking hard enough for extreme events
- limits of predictability
- relative importance
- how will Arctic communities adapt to unprecedented changes and are there thresholds of adaptation with respect to extreme variability, extreme states and events, extreme rates of change

2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes

What is the impact of this uncertainty on our understanding of the Arctic System?

- high

2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes

What is our level of confidence in the above assessment?

- high for paleo record; high for some co-varying data (such as Larry's fishery collapse report); high for some ecosystem models depending on scale; low for dynamic models; medium for societal models

2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes

What is our level of readiness to deal with this uncertainty?

- high for re-analysis of already existing co-varying data; medium for new cross-disciplinary efforts (mathematicians are ready)

2. The Nature and Importance of Threshold Events, Extreme Events, and Abrupt Changes

Should this focus area be addressed by a new or existing initiative, by one or a combination of existing ARCSS components, or by some other means?

- good avenue for cross-directorate Announcement of Opportunities (mathematics, LTER, OPP, SBE, GEO)

3. Defining the Extreme States of the Arctic System

- how far can it go
- bumpers on separate quasi-steady states (ice-covered vs. ice free)
- how do you recognize an extreme state (vs. extreme event: persistence time-scale)
- how likely – frequency
- multiple quasi-steady states
- what can we learn from combining the paleo record and the models – what else happens with ice-free arctic
- other 10-100 year examples: deep convection; ecosystem collapse (ecosystem shifts to lower trophic levels – return to Cambrian ocean); phase-lock of natural oscillation (AO); depopulation; species extinction; new CO_2 levels; oil impacts; permafrost degradation

3. Defining the Extreme States of the Arctic System

What is the impact of this uncertainty on our understanding of the Arctic System?

- moderate to high, with high relevance (40% ice loss, or 10% + hiding)

3. Defining the Extreme States of the Arctic System

What is our level of confidence in the above assessment?

- low

3. Defining the Extreme States of the Arctic System

What is our level of readiness to deal with this uncertainty?

- high

3. Defining the Extreme States of the Arctic System

Should this focus area be addressed by a new or existing initiative, by one or a combination of existing ARCSS components, or by some other means?

- PARCS, SEARCH

4. How to Produce Useful Scenarios of the Future

- sort out non-linear thresholds from organized change
- scenario choices – multiple possibilities
- pathways of change
- can include probabilities
- start with communities; what is the question; who is end user
- model assessment; what is necessary for GCM and regional models
- user-defined scenario generation; type of model depends on users
- confidence depends on having clear assumptions
- needs and information base
- what outputs of climate, oceanographic, and ecosystem models of change respond to community concerns

4. How to Produce Useful Scenarios of the Future

What is the impact of this uncertainty on our understanding of the Arctic System?

- NA: wrong question – scenario is application of information

4. How to Produce Useful Scenarios of the Future

What is our level of confidence in the above assessment?

- NA: wrong question

4. How to Produce Useful Scenarios of the Future

What is our level of readiness to deal with this uncertainty?

- NA

4. How to Produce Useful Scenarios of the Future

Should this focus area be addressed by a new or existing initiative, by one or a combination of existing ARCSS components, or by some other means?

- HARC is already doing some of this
- *We are dumb scientists, society! Tell us what you need!*

5. Sorting out the Interactions Between Global and Arctic Modes of Variability

- harmonize Arctic with global program – ASOF, CLIVAR
- polynyas – international program
- relative importance of internal vs. external modes of variability; interactions and relationships between the ENSO, PDO, AO, others
- ecological impacts: river basins southern limits, contaminants, animal migrations, circulation changes
- impact changes in the deep convection; salinity anomalies
- changes in private and government policies; new technology
- understanding the stratosphere – ozone hole
- CO_2 radiative trace gases
- what other local and global changes have taken place that affect the ability of Arctic residents to adapt to environmental change

5. Sorting out the Interactions Between Global and Arctic Modes of Variability

What is the impact of this uncertainty on our understanding of the Arctic System?

- very high – how open is the system

5. Sorting out the Interactions Between Global and Arctic Modes of Variability

What is our level of confidence in the above assessment?

- very high – need to tie in with larger communities

5. Sorting out the Interactions Between Global and Arctic Modes of Variability

What is our level of readiness to deal with this uncertainty?

- different states of readiness:

  - positive readiness: contaminant transport

  - negative readiness but improving: global climate modeling

5. Sorting out the Interactions Between Global and Arctic Modes of Variability

Should this focus area be addressed by a new or existing initiative, by one or a combination of existing ARCSS components, or by some other means?

- Evil axis of SEARCH, CLIVAR, and ASOF