Summary of the Climate Dialogue on Arctic sea ice

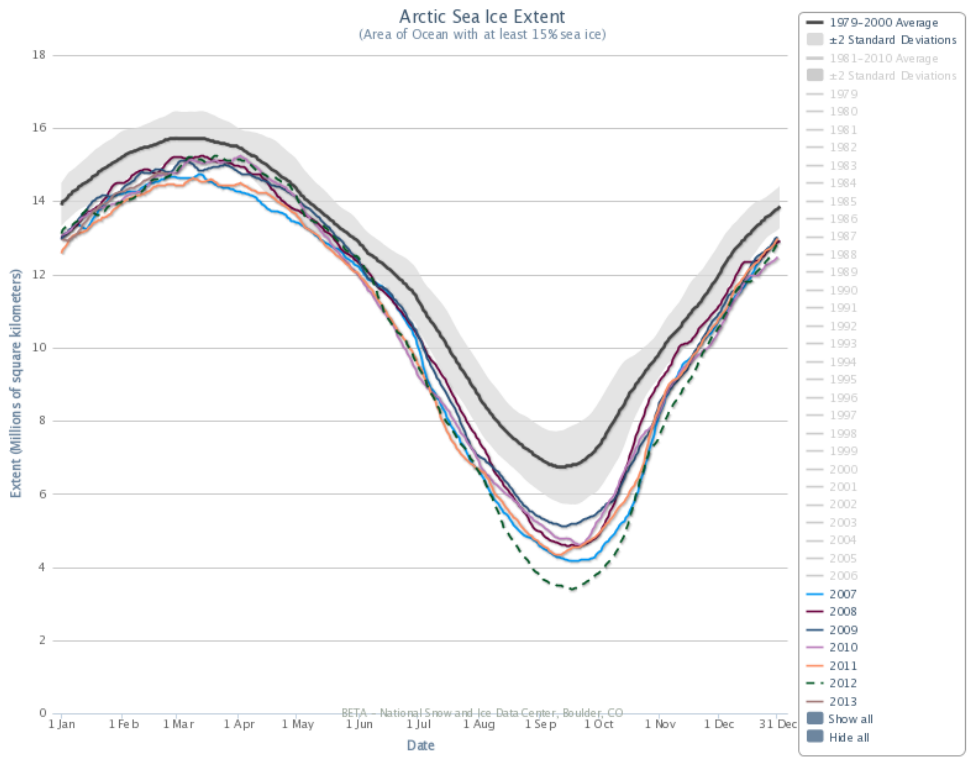
The decline of Arctic sea ice is one of the most striking changes of the Earth's climate in the past three decades. In September 2012 the sea ice extent reached a new record low after an earlier record in 2007. Both ice extent and volume have decreased steadily and if things will continue this way the Arctic will be ice free in the summer some year in the future.

Given the recent new record the melting of the Arctic was the logical choice as the first topic on this new Climate Dialogue platform. We are very glad that Walt Meier, Ron Lindsay and Judith Curry took up the challenge to engage with each other. We also like to thank the many climate scientists and other interested readers who joined the discussion via the public comments. We had over 25,000 hits in the first three weeks, which exceeded our expectation for the first round of discussion.

This summary is solely based on the contributions of the three invited scientists Walt Meier, Ron Lindsay and Judith Curry. It's not meant to be a consensus statement. It's just the summary of the discussion and should give a good overview of how these three scientists view the topic at this moment, i.e. on what they agree and disagree and why. In our introductory article we presented six questions and we will treat each one separately.

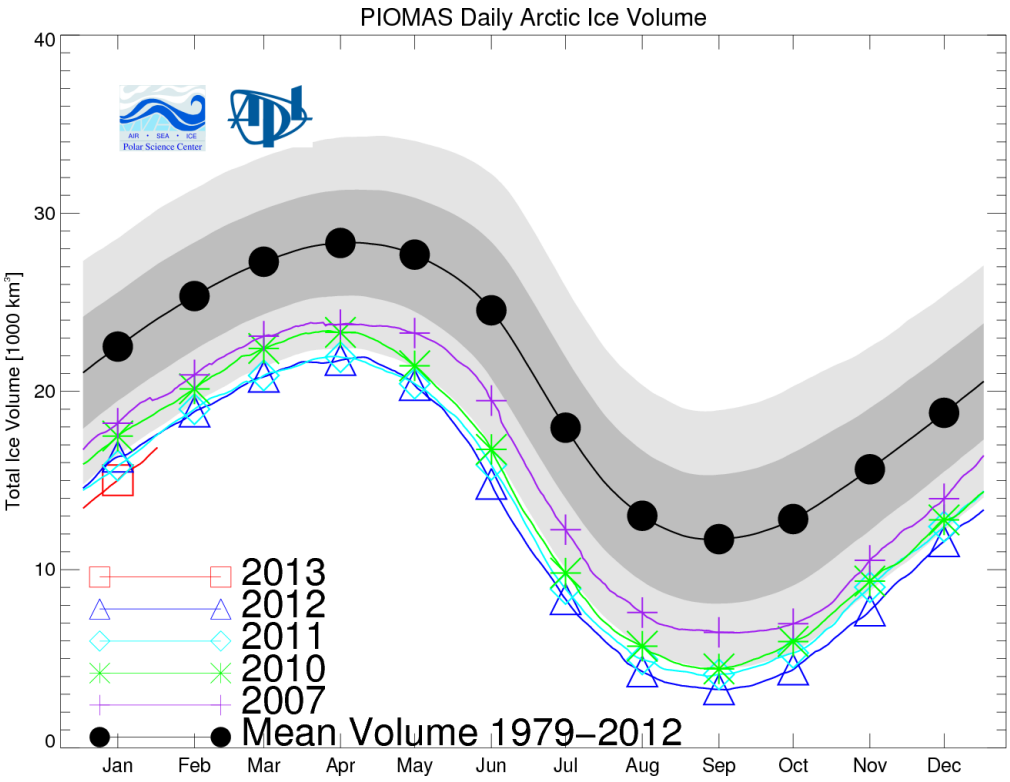
1. What are the main processes causing the decline in Arctic sea ice?

Over the last 30+ years, Arctic sea ice has declined precipitously, particularly during summer. Summer ice extent has decreased by ~50%, including most of the older, thicker ice.



Source: http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/

Sea ice volume has decreased even more, with the monthly averaged ice volume for September 2012 of 3,400 km3, which is 72% lower than the mean over the period.



Source: http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/

There is no disagreement about these facts. However, it is less clear what are the main processes that caused the decline.
The discussants agree that relatively little heat (~0.5 W/m2) is necessary to explain the decline of Arctic sea ice in the past three decades. These changes are so small that our observational systems are unable (yet) to detect the main sources for this trend.
The discussants agree that in general melting from the ocean is much more effective than melting from the air. However there is little evidence that transport from either the Atlantic or the Pacific contributed much to the melting in the past decades.
A number of processes seems relevant: earlier snow melting in spring leads to melt ponds in the sea ice, opening the Arctic ocean for incoming solar radiation, which then melts the ice from both above and below the ice. Clouds are also an important player in these processes, although not much is known about the trends in clouds in this area.
The discussants stress that it's difficult to separate cause and effect. The major forcings and feedbacks influencing the Artic sea ice can change from year to year.

	Meier	Curry	Lindsay
The decline in sea ice *extent* since 1979 is very well documented/undisputed	5	5	5
The decline in sea ice *volume* since 1979 is very well documented/undisputed	5	4	5

Two thirds of the melting each summer is taking place from below the ice	3	x	x
Earlier snow melt in spring is playing a big role in the summer melting	4	4	4
By far the largest component causing the seasonal melting is the solar flux	5	5	5
The influx of warmer waters from the Atlantic has played a minor role in causing the decline in Arctic sea ice	x	x	x

Scores (don't know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)

2. How unusual is the current decline in historical perspective?

Lindsay and Meier have more confidence that the current decline is unprecedented in historical context. Curry stressed the lack of data before 1979 which hampers our understanding of the state of Arctic sea ice in the past. Meier on the other hand mentioned several studies that shed light on past sea ice conditions and how they differ from the current situation. The participants agree that during the Holocene Thermal Maximum (around 8000 ybp) the Arctic likely was ice free or near ice free as well in the summer. At that time temperatures in the Arctic were similar as today or even higher.

	Meier	Curry	Lindsay
The current decline in ice extent is unprecedented in the *last century*	5	4	5
The current decline in ice extent is unprecedented in *the last two millennia*	3	x	3
The current decline in ice extent is unprecedented in the *Holocene*	3	x	2

Scores (don't know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)

3. Is there evidence for a substantial role of natural variability?

The discussants agree that a shift in the Arctic Oscillation (AO) in the late 80s seemed to have started the decline. A positive AO, especially in winter, pushed older thicker ice out of the Arctic through the Fram Strait. When the AO went back to normal however, the decline in sea ice continued. Meier and Lindsay conclude from this that oscillations like the AO, but also the NAO and PDO, probably played a minor role in the continuing decline. Model simulations suggest that the AMO might have contributed between 5% and 30% of the melting. Curry is not so sure about this. She mentions a hemispheric climate shift in 2001 that accelerated the decline followed by a local regime shift in 2007, that has resulted in all the minima since then being well below normal, with a high amplitude seasonal cycle. Lindsay and Meier also have more confidence in the models than Curry. Lindsay said it isn't likely that they hugely underestimate natural variability, but this is exactly what Curry thinks the models do.

	Meier	Curry	Lindsay
A shift in the AO to positive values started the decline in the early 90s	4	4	4
Now that the ice is thinner, the effect of natural oscillations on the sea ice	4	3	4

trend is much smaller			
Models underestimate natural variability considerably	2	5	1

Scores (don't know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)

4. What is the role of 'global warming'?

There is disagreement about the role of global warming. Both Lindsay and Meier sum up evidence for a large role of "global warming" in the current decline in sea ice. Lindsay mentions the good correlation with the Northern Hemispheric temperatures, showing that the sea ice is not on its own regional trajectory but follows the trend of a larger area. Meier notes the fact that the warming now is pan-Arctic and outside the range of natural variability for the last few centuries. Curry acknowledges a role for global warming to the longer term trend. But at the same time she notes that locally any radiative forcing from greenhouse gases is swamped by inter-annual variability in cloud radiative forcing.

	Meier	Curry	Lindsay
The evidence for a substantial role of "global warming" in the current Arctic sea ice decline is very strong	5	4	5

Scores (don't know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)

5. Quantification of the anthropogenic contribution to sea ice decline

The participants agree it is unlikely the contribution of greenhouse gases to the recent decline is lower than 30%. Curry even said she wouldn't know any publishing climate scientist going lower than 30%. Curry proposed a range of 30 to 70% greenhouse gas contribution to the recent decline in sea ice extent. Her best estimate would be 50%. Lindsay agreed with this best estimate of 50% for extent. He added though that sea ice volume is his preferred metric because it shows less year to year variability. For sea ice volume he would go higher, say 70%. Meier proposed a smaller range of 50 to 70%.

	Meier %	Curry %	Lindsay %
What is your preferred *range* w.r.t. the contributions of *anthropogenic forcing* to the decline in *sea ice extent*?	50-95%	30-70%	30-95%
What is your preferred *range* w.r.t. the contributions of *anthropogenic forcing* to the decline in *sea ice volume*?	50-95%	30-70%	30-95%

Scores (don't know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)

6. Could the Arctic be ice free in the near future?

None of the participants is very enthusiastic about the idea that the Arctic could be ice free in the summer within a few years. Meier explained that so far the “easy” ice has melted but that now we’re getting to the “more difficult” ice north of Greenland en the Canadian Archipelago. “The predominant ice circulation pushes ice toward those coasts resulting in thick ice that tends to get replenished.”
Lindsay is most confident that even on a time scale of one or two decades greenhouse forcing should cause a further decline. Curry emphasized that on this time scale natural fluctuations will dominate the effect of CO2. For her a reverse of the trend is therefore possible. Meier “wholeheartedly” agreed with Curry that decadal prediction of sea ice is going be very difficult.
Curry stated that the currently used definition of “ice free” (being less than 1 million km2 of ice) is misleading as it is not really ice free. Meier defended the definition as being valid for all practical purposes like ship navigation, the albedo feedback and impacts on the ecosystem.
None of the participants believe in a tipping point. Lindsay noted that if we magically could turn off the forcing the sea ice could recover pretty quickly. Lindsay: “Unfortunately that is not likely to happen.”

	Meier	Curry	Lindsay
The Arctic could be ice-free in a few years	1	1	1
The sea ice could (partly) recover in the next two decades due to natural variability	2	3	2
What is the most likely period that the Arctic will be ice free for the first time?	2030-2050	x	2020-2060

Scores (don’t know=x, very unlikely=1, unlikely=2, as likely as not=3, likely=4, very likely=5,)