An EPIC Project:
Social Science Recommendations
to Build Community Modeling

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Acknowledgements

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Executive Summary

Since Superstorm Sandy, there has been a large focus on community modeling in the government sector. This has led to the creation of the Unified Forecast System (UFS), an initiative to use a common framework for earth prediction modeling in the United States. Additionally, Congress mandated the creation of the Earth Prediction Innovation Center (EPIC) to help facilitate a community around this framework and move model innovations into operational forecast models. However, the concept of "community modeling" is not well defined, despite the many models that are described as such. In order to help EPIC facilitate a strong community model with the UFS, this project examines what it means to be part of a modeling community using a social science perspective. Using qualitative interviews of key stakeholders with the UFS and EPIC programs, we investigated the elements of community modeling, and how the UFS compares. Through the lens of the Sense of Community framework we identify several findings from community members. For a deeper discussion of each finding use the link to the relevant section in the full document.

Findings:
- Members indicated there is a need to focus more on building the community

([Social Elements](); [Shared Emotional Connection]())

- Members want ways to connect to each other to share knowledge, ideas, and things that did not work, not just new innovations ([Collaboration]())
- Members want those who are actively contributing as part of the community ([Collaboration]())
- Different sectors have different expectations which means that members are motivated differently ([Sector Perspectives](); [Shared Emotional Connection]())
- There is no reward structure for members of the community ([Sector Perspectives]())
- Atmospheric modeling generally feels included, but other areas of earth modeling are not currently included in the framework ([Membership]())
- There is confusion between the UFS and EPIC and what they are are designed to achieve ([Membership]())
- Competition in how models are selected, and a non-transparent decision process, for the UFS framework discourages some members who utilize these models from participating ([Membership]())
- Outside of NOAA, members do not feel they have influence on the governance structure of EPIC which discourages them from participating. ([Membership]())
- There is often a difference in how researchers and operations design code and the timelines they follow ([Membership]())
- Members understand it takes time to build trust, and that EPIC is not going to happen overnight; they are looking forward to the possibilities in the future ([Shared Emotional Connection]())

Based on these findings, we have recommendations for the EPIC team based on a Community of Practice framework. These recommendations are based on all of the findings collectively as described in the detailed discussion of the full [EPIC Recommendations]() section.

Recommendations:
- [Increase Transparency and Communication]()
  - Establish shared communication between EPIC and the UFS to decrease confusion between the initiatives
  - Provide regular updates about the work EPIC is doing
- [Build Platforms to Connect Members]()
  - Establish ways for members to directly engage with other members
  - Build systems that are similar to existing ones that users already know how to navigate
  - Inspire empathy across the sectors by creating co-working environments
- [Motivate Participation]()
  - Use emerging leaders to serve as "EPIC Ambassadors" to help bring in new members from each sector

- ○ Create ways to reward members for their work, both technical and social, such as mentoring
- ○ Make these rewards fit the values of each sector. Members from different sectors will be motivated differently.
- ○ Provide funding to encourage more members to join the community
- Ongoing Rigorous Assessment
  - ○ Investigate who is in the community, and their needs for being part of the community, using social science methodologies
  - ○ Measure the "sense of community" within current membership using existing frameworks
  - ○ Conduct annual assessments to see how the sense of community and community member needs change

Introduction

It is well documented that weather plays a large role in our daily lives, not only individually, but as a nation. For that reason, it is vital that we have advanced technology that allows for the best possible prediction and forecasts. For many years, the United States was the leader of advancements in understanding and predicting the weather. However, after Superstorm Sandy in 2013, several well-known figures within the weather enterprise started calling attention to the idea that the U.S. was falling behind other nations' models, specifically the European Model (Mass, 2006).

Several years prior to Superstorm Sandy, the National Oceanic and Atmospheric Administration (NOAA) initiated a review of all centers under the National Centers for Environmental Prediction (NCEP). This review, conducted by experts external from NOAA, resulted in many recommendations to improve earth prediction, especially tied to modeling. One of the recommendations was to move to a unified system for all earth modeling (Tolman & Cortinas, 2020). This recommendation, in part, led to the creation of the Unified Forecast System (UFS), which is designed to be a common framework for all earth modeling in the United States (Carr et al., 2018). This includes modeling of aerosols, the atmosphere, the ionosphere, land, oceans, sea ice, storm surge, and waves. The creation of the UFS relies on the concept of "community modeling".

The term "community modeling" has been used in several different contexts over the last 20 years to describe a range of modeling initiatives. However, no specific definition has been proposed to fully describe what it means. In 2018, the Earth Prediction Innovation Center (EPIC) was created, in part, to help develop community modeling in the US. Without a full understanding of what it means to be part of community modeling is it difficult to build a community. In order to fill this gap, Michael Michaud, a William M. Lapenta Intern was tasked to better understand what it means to be a community and how EPIC can build and support this community. This report summarizes foundational literature on communities, analyzes key stakeholder

interviews from UFS and EPIC pioneer community members, and makes recommendations for the EPIC team to continue developing their program.

Background

Before investigating what "community modeling" means, it is important to consider what it means to be part of a community, and how community modeling developed. This section offers a brief look into the conversation around communities. It then reviews how this knowledge can be applied to community modeling. Finally, it provides background on the creation, and vision, of EPIC.

What is a Community?

Before diving into community modeling, it is important to ask what is a community? A community is not well defined within the academic literature. In one of the most cited papers on community, Gustfield (1975) suggests that there are two components of community, geographical and relational. Geographical is the aspect of being in close proximity with others. Relational is the "quality of character of human relationships without reference to location" (p. xvi). In other words, how people relate to each other. Gustfield (1975) noted the key aspect is relational, as simply being in close proximity to others may not lead to a feeling of a community.
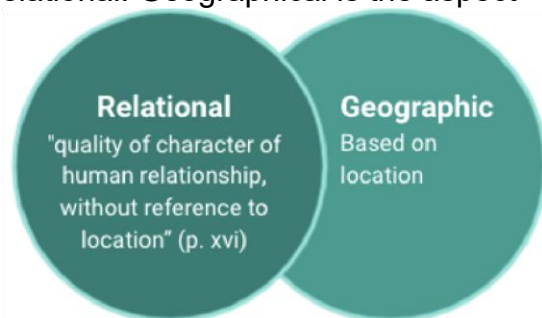
Figure 1: Elements of Community (Gustfield, 1975)

Rather than focusing on the definition of community, many scholars have focused on examining what it means to have a "sense of community", an idea first developed and defined by McMillan and Chavis (1986). Their framework includes four different parts:

- ○ Membership - feeling of belonging and relating to others
- ○ Influence - mattering and making a difference in the group and being important
- ○ Integration and fulfillment of needs - members have necessary resources in the group
- ○ Shared emotional connection - commitment by members to the group and feeling they have similar experiences and values
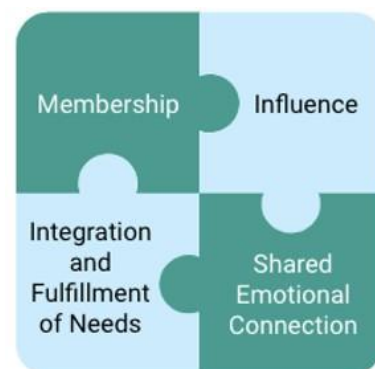
Figure 2: Elements of a Sense of Community (McMillian & Chavis, 1986)

Many other scholars have developed ways to measure a sense of community through simple survey questions. They range from as few as eight questions (Peterson

et al., 2007), up to over fourteen (Puddifoot, 1996). While there are mixed opinions on instrument quality, the general consensus is these can be useful in many cases (Long & Perkins, 2003; Peterson et al., 2007).

With a theoretical understanding of what constitutes a community and a sense of community, we shift focus to the modeling aspects.

What is Community Modeling?

Unsurprisingly, there is no common definition for "community modeling" in the academic or trade literature. Within the atmospheric science field, the Climate Systems Model developed by the National Centers for Atmospheric Research (NCAR) in 1996 was the first that used a community model approach. They defined their goals as: "making the model readily available to, and usable by, the climate research community, and to actively engage the community in the ongoing process of model development" (Blackmon et al., 2001).

Today, the UFS framework outlines what community modeling includes, but it does not offer a specific definition. It identifies the users and the roles they have, but does not define what it means to be part of the community (Carr et al., 2018). The focus for both of these definitions is on the framework itself and not the people. As we saw in the theoretical community definition, the important part is bringing people together to foster a *sense* of community. Several of the planning documents for the UFS even identified the need to have a common definition of what it means to be part of the community, but it seems one was never fully developed (Tolman & Cortinas Jr., 2018). This leads to the research question for the project, what is community modeling? To do this, we wanted to explore how community members define "community modeling."

The Earth Prediction Innovation Center (EPIC)

In 2018, Congress passed the The National Integrated Drought Information System Reauthorization of 2018, which amends the Weather Research and Forecasting Innovation Act of 2017, creating EPIC, which was tasked to accelerate communitydeveloped enhancements to operational modeling (Cikanek et al., 2019).

This includes:
- removing barriers to developing models outside of NOAA,
- enabling better collaboration between scientists and engineers, ● and creating a global research model that is accessible to the public.

In short, EPIC is building partnerships with the modeling community to innovate the US forecast models.

This project focuses on how the existing community of modelers perceive or feel invested in the UFS community and EPIC, and how EPIC can build a stronger community.

Methodology

The purpose of this study is to better understand what "community modeling" means, and how a community can be built by the EPIC program to support the UFS community. Since this is an exploratory study with limited background information, it is appropriate to use a qualitative approach. Qualitative research allows for a greater indepth examination of a phenomenon (Patton, 2015). Additionally, using an interview technique allows the researcher to gather in-depth information from participant's perspectives (Patton, 2015). In order to maintain consistency in interviews, but have flexibility to explore different themes, we implemented a semi-structured interviewing instrument. The full instrument is listed in Appendix 1.

We used a key informant sampling method (Patton, 2015), which allowed us to hear perspectives from those who have been included with the UFS and EPIC for a significant amount of time.

Participants were identified from all three weather, water, and climate enterprise sectors including government, private companies, and academic institutions. We intended to have an equal sample from each sector; however, it was difficult to get a response after several contact attempts with private companies. We also spoke with weather, climate, and ocean modelers.

There were seven participants from the public sector, five from academia, and two from the private sector, for a total of 14 participants. Seven participants were external from NOAA, therefore we did not need to complete the Office of Management and Budget Paperwork Reduction Act process.

Interviews lasted about an hour each, but some were limited to a half hour due to time constraints. Interview topics included defining "community modeling", differences between UFS and EPIC, perceptions of UFS and EPIC, and sector values.

Interviews were recorded using Otter.Ai which also provided transcripts of the conversation. Using an inductive approach, we looked for common themes among the sensitizing topics of: community modeling definition, UFS and EPIC differences, community perceptions, and sector values.

Defining Community Modeling

From our conversations, we identified several elements that should be included when defining community modeling. They can broadly be grouped into technical requirements for the community and the social aspects of belonging to a community. When asked "what is a community model", everyone, with two exceptions, went right for

the technical aspects, and what they saw as the needs for technical infrastructure. This included elements of being open source, so anyone can access or use the code, and open development, where anyone can change the code and submit innovations back into the model. Several called this a "sandbox" or "playbox", where researchers could innovate and play with different tools to improve the model. Most participants also mentioned the importance of being able to run the model across all platforms with the benefits of cloud computing. One participant even shared the example of a community member using an Xbox to run the code.

After some brief comments about the technical aspects, many participants instinctively started to discuss the more social elements about belonging to a community, and the need to connect with others in the community. This section will focus on the social aspects, as they were noted as the pieces typically missing from current conversations about community modeling.
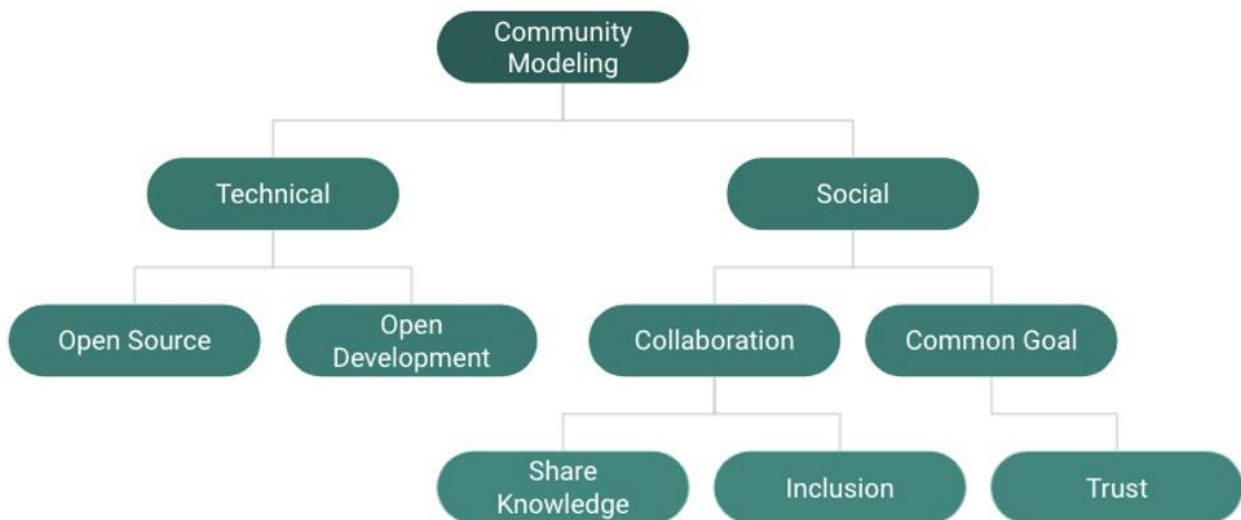
Figure 3: Elements of Community Modeling

Social Elements

From our interviews there were several important elements within the social realm of community modeling. These include the importance of creating a shared goal and collaboration. Each element plays an important role in understanding what it means to bring together a community model.

Common Goal

Almost every participant mentioned the need to define a goal that is set by the community for everyone to work towards. Sometimes, this means member's primary goals must take a back seat if they are going to be active in the community. By committing to a shared goal, there needs to be a great deal of trust between members. Participants discussed that there needs to be trust in other members that everyone is committed to the shared goal and are not working against each other. Several participants also mentioned the need for trust in governance and knowing that members

have a say in the direction of the community. Other participants also mentioned the need for trust in the code, that members are submitting code that works and is not malicious.

Collaboration

Another element identified was the ability to collaborate among other members. Participants mentioned the need to share knowledge with others who were working on similar projects. Many different examples were shared including regular in person workshops and conferences, online help forums, detailed code documentation and live code assistance. Several also noted the importance of being able to share things that did not work, just as much as things that did work.

The other element of collaboration is inclusion. For the most part, participants said the community should be open to everyone. Some explicitly listed all three sectors (public, private, academia), researchers, operations, and even high school students having the ability to be part of the community. Several participants noted that there may be barriers to participation, including technical understanding and computing ability. Two participants also noted that anyone who is part of the community is a volunteer. Community members have to self-select to be part of the community, and can choose to leave at any time. This highlights the importance of keeping members engaged.

About half of the participants explicitly said no one should be intentionally excluded from the community, with the exception of national security concerns. The other half of interview participants noted that in order to be part of the community, you should be contributing in some way. Some participants cited the concern that members may use the code to advance their own goals without giving back to the wider community.

Combining the Technical and Social

Taking a step back, it was quite enlightening that almost everyone first mentioned the technical aspects of community modeling, but given the time to talk through their definition, focused on the social pieces. There has been so much attention, and money, placed on the technical aspects of community modeling over the years, but little in the way of community development.

Moving forward, there needs to be a focus on developing both the technical aspects of community modeling as well as the social aspects. They can help inform each other and build on each other. From the social elements, we can learn what users need, which can then be developed into technical advancements. The technical aspects can also support the social network by building the knowledge members use together.

Sector Perspectives

It is also important to consider how the different sectors within the enterprise operate. One of the key elements of community modeling is having a shared goal. Across the different sectors, goals do not always align, although individual goals can often be used to create a shared goal. But further out of alignment are the reward systems for the different sectors, and even how people within each sector view other sectors. For example, in the public or government sector, they focus on having the best operation models to improve forecasting. Private industry wants to capitalize on the best innovations that competitors do not have. In the academic world, research and publications are what drives success. Often, helping to improve the national operational model does not help an academic get funding, or publish a paper. Developing some innovation that none of your competitors have means nothing to the National Weather Service. It is crucial to understand how these different views can interest, and sometimes be detrimental. In the interviews, there were a number of assumptions on how "the other" sectors operate. While there may have been some truth, there are many misconceptions, which can have very negative impacts on the community.

This is also where EPIC needs to focus in the future. They need to find a way to bring people from different sectors together in community modeling. EPIC needs to find ways to keep everyone motivated by helping to create reward systems that work across the sectors and meet the needs of every member. This is not an easy task as research shows, but there are a number of methods that could be used. Social scientists and other experts can provide significant value in these areas.

Sense of Community within UFS and EPIC

With a general understanding of the elements of community modeling, we can look more closely at the sense of community within the UFS and EPIC community. Using the framework proposed by McMillan and Chavis (1986), we examine how well key stakeholders feel a sense of community.

Membership

Membership is the feeling of belonging and being able to relate to others within the group. Generally, within the weather community, most participants indicated that they felt included. Keeping in mind many of them helped create the UFS or EPIC and therefore can have some biases. Participants indicated that their work closely aligned with the common goal of improving forecast models. However, there were participants who felt their current line of work was excluded. Participants outside of atmospheric modeling seemed to be more disconnected since the UFS has not yet expanded to the other seven components. They did however show optimism that they would eventually be included, and they seemed engaged in the other aspects of community modeling more broadly.

Between participants, there was some confusion about the difference between the UFS and EPIC. When asked about the difference between the two entities, every participant had a different response, with some varying greatly. Some saw EPIC as a center for sharing and filtering ideas to understand what others are doing with the UFS community. Some mentioned that EPIC will serve as a funder for research and innovation for model development within the UFS. One participant saw the UFS as a structure set up by EPIC for development. There were also concerns from one participant that EPIC was trying to replace the UFS. Every participant seemed confident in their understanding of what EPIC is, although they had different ideas than others. One participant even mentioned that within NOAA, no one is fully aware of what EPIC is supposed to do. This shows that while most indicated they felt included within the community, they may be unaware of how they fit in with others.

A few participants also noted that the way the UFS is structured may discourage someone from wanting to participate. Currently, in order for a model to get into the UFS framework, there is a competition to see what is the best model. Some participants noted that this competition discourages collaboration and anyone who supports the losing model may not want to join the community.

Influence

Influence is the feeling of making a difference to the group and feeling important. Within academic sector participants there were mixed feelings of influence, specifically with the governance structure. About half of the academic participants noted concerns that as non-government employees that are part of a government funded and controlled program, they would not be able to help steer future directions as they might expect from a true community model. Participants in the government sector mentioned this from a different view. Given the Congressional mandate for EPIC, and the associated funding, there is specific accountability that makes it a necessity for some form of government oversight. This shows there are likely to be disagreements about how EPIC is structured that will need to be addressed.

Several participants also mentioned a divide between research and operations. One participant succinctly mentioned that, in their opinion, about half of academics are interested in making their research operational and working towards improving modeling for the benefit of the nation. They are the ones who are likely to be involved in and influencing the community. The participant noted that the other half may not see a benefit, either because they are not receiving funding, or because helping NOAA does not satisfy their academic expectations. This means they are likely to not be involved because they do not see a role for themselves in the community.

Integration and Fulfillment of Needs

In order to have a sense of community, members also need to have their needs met, in this case both technically and to share knowledge. We previously explained

many of the ways participants would like to be able to connect with other community members to share knowledge and receive assistance with the technical aspects of modeling. Several participants also noted the need for allowing members from different backgrounds to integrate their knowledge and sharing these experiences to build synergy between members. This ongoing conversation shows that needs are not currently met, and need to continue to be built.

There were some concerns that the technical infrastructure was the focus for building EPIC, but there has not been enough emphasis on building the community. Some of these concerns related to the choice in EPIC contractor which, in the participants' opinion, has the technical knowledge but not the experience in building communities.

Shared Emotional Connection

There was evidence that each sector has their own values, goals, and success metrics that are not always in line with each other. This has been well documented in the National Academies Fair Weather report in 2003, which was interestly mentioned by name by three participants. This divide indicated that there may be a lack of emotional connections between those in the different sectors, stemming from their different professional goals and needs. Aside from these differences, many participants did mention a common goal of working towards bettering forecasting for the nation. This shows there are some shared emotional connections broadly across participants, but it is important to notice some of the sector differences. Most notably, there was distrust in the academic sector towards government and private industry.

Given the small sample from the private sector, it is difficult to infer how dedicated they are to being part of the community. Participants in the government and academic sectors voiced concerns that the private sector may use the code for their own advancements while not giving back to the wider community. One participant claimed this is the exact reason why private companies need to be valued partners to help drive to a shared vision.

Most of the participants also recognized that EPIC was still in the development stages and were optimistic about the future. It is important to recognize that this is not a representative sample of the full community, but rather key stakeholders that have been very involved with setting up the UFS and EPIC communities. A wider study of community members is needed to fully assess a sense of belonging throughout the entire community.

There is evidence that community members are already shifting their mindset to the importance of the social factors of community modeling. Members want to feel a sense of community, as evidenced by several selected quotes:

*"It's a unified forecast system in the sense that the code base is a single code base, but it's also unified **because they build a community that unifies people** inside the Weather Service and outside the Weather Service"*

*"I'd like to make **my community** part of that community, but it's not like you can just toggle a switch. There has to be **desire, trust and acceptance** on all parties to some level to **make this successful**."*

*"In order for a community of practice to thrive, **everybody has to get something out of it**, otherwise they're going to stop showing up."*

*"I believe we need to invest in that, and **invest in tools that bring the community together**... to organize and cultivate this community, **it's not going to come together on its own**."*

*"And a lot of it was just getting expectations, aligned and set up properly and **getting the trust on both sides and it took time**... the key is, getting people in the room, and talking and communicating and building the trust. **Without trust, none of this works.**"*

Members understand trust is an integral element and that it takes time for community building to happen. One participant even called out the notion of the "Build it and they will come" mantra that was often used to describe EPIC. They noted that it takes work to build the community, they will not simply come. The question now becomes, how do you organize and build a community?

EPIC as a Community of Practice

Based on the perceptions of the community, and specifically identified by one participant, EPIC is trying to develop a community of practice around the UFS. Why is this important? There is a large body of literature that focuses specifically on how to develop and maintain communities of practices that EPIC can utilize.

What is a Community of Practice

The definition of "community of practice" is evolving. One of the more recent explanations by Wenger (2011), who coined the term, defined it as " groups of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly" (p. 1). In order to be a community of practice, the group needs to have a shared domain, in this case modeling. They build community by creating relationships to learn from each other. Given the attendance at professional conferences, you can see that this element already happens. The final part is practice, where members develop experience and knowledge together. This is exactly what EPIC hopes to achieve within the UFS framework based on the vision. It is important to recognize there are likely to be multiple communities of practice within EPIC, given that modeling can be quite different between the eight different UFS components.

Figure 4: Elements of a Community of Practice (Wenger, 2001)

There has been significant research on communities of practice. Most notable is that they are organic and have an informal structure (Hemmadi & Csanda, 2009). Because of this, it is often hard to build a structure supporting them. Typically, leaders will emerge from among the members as those who have developed a strong amount of trust over time. It is also important to recognize that communities of practice are inherently voluntary (Hemmadi & Csanda, 2009). Members will only join and stay engaged if they develop a sense of community as previously discussed.That is why it is important that there are resources to help build and support the structure, even if it is informal. Overall, communities of practice have been shown to be very successful for building shared knowledge (Smith & McKeen, 2004).

Community of Practice Framework

To support their work as a community of practice, EPIC can follow a framework like one by Smith & McKeen that outlines how to help build and maintain a thriving community of practice.

Figure 5: Community of Practice Building and Maintaining Framework (Smith & McKeen, 2004)

Building Community

As EPIC is still in the early stages, it is important they recognize how to build a community. This includes the elements of identifying, facilitating, managing, providing technology, and building a culture for the community, as explored in the following sections.

Identify

First is identifying communities that already exist and helping to form them into a community of practice. There is already a community of modelers and those who use the UFS. Within these larger communities, there are also many different smaller communities that work on specific modeling components. EPIC needs to identify these communities and their existing networks to help cultivate them into a community with a sense of belonging.

Facilitate

Support needs to be provided to members of the community. In our interviews, participants specifically mentioned the needs of technical systems, user support, code documentation, and ways to communicate, like user forums, workshops, and training. The technical systems are being built, but there needs to be added emphasis on the social infrastructure for members to connect and build knowledge.

Manage

The EPIC Team needs to bring together people who are knowledgeable, rather than trying to manage what happens. For EPIC this means bringing the players from all three sectors together, as well as researchers and operations, and ensuring there is significant expertise. As EPIC expands, it also means there should be representation from all eight UFS components.

Technical

Having usable technical infrastructure is a key element of success, as EPIC has already noted. Research shows that meeting the needs of community members helps build the community. The key is fully understanding what those needs are and working with community members to constantly assess technical tools and future needs.

Culture

Community members need to feel a sense of belonging within the community. This includes making sure members understand each other and the different viewpoints they have. As we have seen, different sectors have different values and metrics of success. EPIC needs to facilitate conversations between these sectors to understand differences and support the development of a common goal. This includes ways for members to come together face-to-face (pandemic permitting) and provide time to discuss their work and their ideas. One participant did allude to a shift to a more collaborative culture with the Enterprise as a whole. Before, it was mostly individual research projects where one researcher was interested in a very specific element. Today, the vision is to encourage researchers to work as teams to research earth modeling holistically since all of the elements impact each other. Examples like this one need to happen on a broader scale across the sectors to come to a common understanding. The end goal is making sure everyone feels like they have a role in the community and feels welcomed.

Maintaining Community

Building a community is only the first step. It is also vital that EPIC continues to cultivate the community to ensure ongoing success by understanding hurdles, making knowledge easy to use, measuring value, developing trust, establishing coordinating roles, motivating people in the community, and continuously monitoring the evolution of the community.

Understand Hurdles

There are hurdles that must be overcome to develop a thriving community. From our interviews, many participants mentioned one hurdle is getting buy-in. The UFS is a new program and, especially within the academic sector, there may be few motivating factors to adapt to a new modeling framework. This means EPIC needs to work closely with members to understand how to get buy-in and expand the community. Others noted the importance of making sure it is easy to join the community, both by learning the technical aspects, as well as being able to share gained knowledge with others.

Make Knowledge Easy to Use

Members must have ways to share knowledge to continue to build scientific understanding. This is currently lacking, and many participants expressed a great need in this area. EPIC should make this a key focus in order to bring members together.

Measure Value

To gauge a community of practice's success, it needs to be able to show value. In this case, value can be measured externally as innovations to the forecast models and improvements in resulting forecasts. This is likely to be measured from a technical aspect. It is also important to consider the value added by members as a whole. Different sectors have their own ways of recognizing value, therefore it can be difficult to find one reward system that will satisfy all members. This needs to be a consideration when deciding how to reward members for their contributions to the community.

Develop Trust

Many participants also mentioned the importance of trust. It seems trust is lacking between the sectors, and even between members in the community that will be needed to reach a common goal. Trust is difficult to achieve, and when it is lost, it is even harder to build. EPIC will need to work closely with members and make them feel included over time in order to build trust.

Establish Coordinating Roles

Many communities of practice have roles individuals play to ensure the community is operational and members have their needs met. They include sponsors (senior managers who show support), champions (organizers of events and communications), facilitator/coordinators (clarifies and keeps members on task), practice leaders (community leaders based on competence), and infomediaries (nontechnicals who share information). It seems that with EPIC there is strong support at the sponsor and champion roles within NOAA. The EPIC team and contractors take on the roles of champion and in some ways, facilitator. Practice leaders need to emerge from the community, but should be officially recognized, and can serve as strong mentors. Infomediaries are not currently found, but could be supported by EPIC or other partners to support the work of the community. As EPIC grows, these roles should be filled and expanded.

Motivate People

There need to be ways to motivate members to be part of the community on top of the intrinsic common goal. Right now, there are no extrinsic motivating factors to be part of the UFS. This should be a key focus for EPIC to build motivation. It is also important to consider that based on the different values of the sectors, there will likely need to be several different ways to motivate members.

Monitor Evolution

EPIC needs to collect feedback from members constantly in order to make adjustments to meet the changing needs of everyone in the community, including developers, researchers, computer scientists, and the users. This study was just a first look at one community within the UFS. It needs to be an ongoing process, supported by social science best practices, to make sure the community is thriving.

EPIC Recommendations

Many participants mentioned visions for what they would like to see from the EPIC program. From these conversations, and from the Smith and McKeen (2004) model, we have proposed four overarching recommendations for EPIC to implement. These recommendations are not sequential, but should rather be considered ongoing processes. Building and developing a community is not a one-time process, but takes ongoing support and effort. Starting with these recommendations will provide an ongoing framework for EPIC to develop and grow.
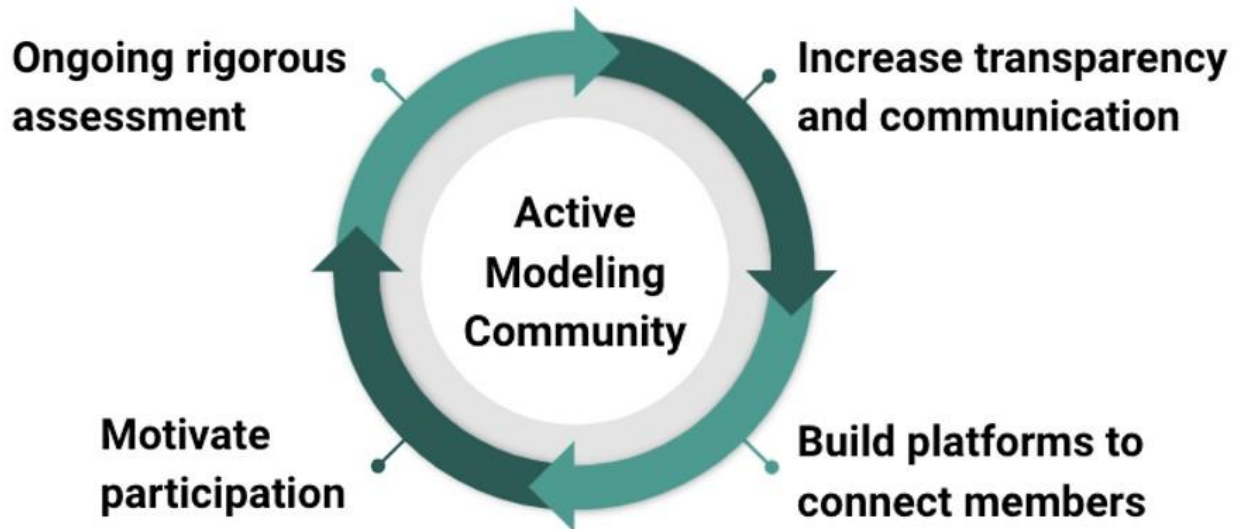

Figure 6: Final recommendations

Increase Transparency and Communication

Over the last year, EPIC has had to limit communication due to the contracting process. Now that the contracting process is complete, EPIC must start sharing information widley and regularly. Given the confusion between the UFS and goals for EPIC, it may be beneficial to work collaboratively on how information about both initiates is dispersed. This should include information about what the UFS is, and distinctly explain how EPIC plans to offer value to the community, both in technical and social dimensions. Any messaging from the UFS or EPIC should be consistent and easily accessible through various media and communication teams for both entities should work together to ensure congruent messaging. This should also include the EPIC contractor to ensure there is consistent understanding about who is responsible for different initiatives and messaging. Messaging should include regular updates to inform the community on changes and upcoming opportunities for engagement. Since it is still unknown exactly who makes up the community, it may be beneficial to have a method for anyone to sign up for regular communications.

Build Platforms to Connect Members

One of the biggest desires from participants was to have ways for members to engage with EPIC as well as other members in the community. Specific examples

included in-person workshops, virtual workshops and training, online discussion boards, live code assistance, and conferences. Several noted the previous EPIC workshop and desired more similar opportunities. Participants also asked for connections that are similar to the Weather Research and Forecasting model, where members can ask questions to the community and get ongoing feedback. EPIC can utilize similar technology that the community is already familiar with, which has the added benefit of quick adaptation. It is also vital to get member input into these tools as they are the ones who will be using them. The tools should meet all user needs, be accessible, and intuitive.

It was also evident participants did not have a clear understanding of the demands and cultures of the different sectors. One participant noted that a program set up to bring operations and researchers closer together in the same physical space took several years for both sides to be on the same page, and even then there was more work that needed to be done in order to gain a full understanding of what the other side does. In the virtual COVID environment, their communication and working relationship has not been as strong as it was in person. EPIC should consider ways to have community members in different sectors working together to better understand their culture and operations within the same physical space, or at a minimum a virtual space. Over time, this may lead to building empathy across the sectors which will lead to a stronger community and sense of community.

Motivate Participation

The community of practice framework, and several participants, noted the importance of motivating members. Motivating participation leads to a stronger sense of community and increased outcomes from the community as a whole. Given the different values and success metrics across the sectors, this is not an easy task. There will likely need to be targeted initiatives for different communities within the larger community of practice. First, in line with the framework, emerging leaders should be used to help motivate and guide their specific communities. While they do not need to become official EPIC employees, they should be recognized in other ways. Leaders who are well trusted could be considered "EPIC Ambassadors", in the way professional organizations recognize leaders within the broader discipline. These individuals could serve as mentors and help build trust within their own communities, which will build trust with the larger EPIC community.

Second, it is important to recognize the contribution of individuals to the community. These may include different awards that are given to those who make significant contributions, either in the amount of innovation, code submitted, or mentorship within the community. These awards may be useful in helping to motivate those in the private or public sector, but the academic sector may need additional recognition. Most of academia places high value on publications. To help motivate those from academia, and also increase knowledge sharing, EPIC may consider creating a new trade or academic journal, where innovations and other scientific advancements can be published. There are many journals, but having a central, easily accessible,

publication may create increased attention within the academic sector. With the increased emphasis on the importance of community modeling, existing organizations may be willing to partner for this new initiative.

Finally, there is also a need for funding support to help encourage motivation. Several participants noted the belief that EPIC was designed to provide funding for researchers to use the UFS. Currently funding is very limited. All avenues should be explored to see how increased funding can be used to help leverage interest and engagement in the UFS community.

Ongoing Rigorous Assessment

As noted in the framework, communities of practice need to be monitored for evolution. The needs of members will shift over time, so it is vital the community shifts with those needs. In addition to shifting needs, there should be a constant pulse on the sense of community. As previously mentioned, this report is based on non-generalizable information. EPIC should begin investigating ways to take a deeper look at the wider community. This should be a rigorous effort grounded in social science methodology and be conducted by those with this expertise with a social science background. This may include metrics for communities, such as the sense of community indexes. After defining what it means to be part of the community and an initial baseline study is completed, there should be yearly assessments to closely monitor the community's progress. Data collected should be used to better understand who makes up the community, what their needs are, who feels included, and what groups feel excluded. Over time, there should be an increase in the sense of community which will lead to the best possible outcomes.

Conclusion

Many participants expressed great optimism for the future of EPIC. They noted that over the last year, there has been a sense of anticipation as the contract was completed and they need to see what develops. Through this study it is clear EPIC needs to focus on building the social infrastructure in addition to the technical infrastructure. Both are needed to work together to create the best possible community model. With these recommendations, EPIC can begin building a thriving community of practice and continue to maintain it for many decades to come. Together, EPIC and the UFS community can build the best forecasting models in the world.

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Appendix 1: Interview Guide

1. First I would like to get to know a little about your background. Can you briefly talk about your current position?
   a. What sectors have you been part of in the past?
   b. What previous positions have you held?
2. When you hear the term "community model" what does it mean to you?
   a. What does "community" mean?
   b. Who is included in the community?
   c. Who is not included in the community?
   d. Do you have a role in the community?
3. Can you talk about your interactions with the Unified Forecast System (UFS) and/or the EPIC program?
   a. How do you see the two entities relating to each other?
   b. What was your vision for the community around the program?
   c. In what ways do you feel included in the community?
   d. How do you feel excluded by the community?
   e. How do your peers perceive the community?
4. I am interested in learning more about how the EPIC program intersects with your professional work?
   a. How does it align?
   b. Where are there conflicts?
5. Can you talk a little about the culture within your workplace?
   a. What are the organizational values?
   b. How does your organization define success?
   c. How are you held accountable for your work?
6. What do you see as the future of:
   a. "community modeling"?
   b. the EPIC program?
7. Is there anything else you would like to add?

Appendix 2: Informed Consent

Thank you for agreeing to participate in this effort to better understand community modeling and the Earth Prediction Innovation Center, also known as EPIC. Before we get started, I would like to tell you more about the project and get your consent to participate.

The purpose of this project is to use the social science literature on building community, in combination with your feedback, to define the community aspects of community modeling. With a set definition of community modeling, we can better develop partnerships between the weather, water, climate enterprise and other sectors as, EPIC

continues to grow. Your participation will help us gain valuable insight into the creation of EPIC and being a member of the modeling community.

The data collected through these interviews will be used to create a report for the EPIC team that outlines a community definition, perceptions of the program from the community, and recommendations to help build the EPIC community. We also anticipate a publication based on community modeling more broadly. Your participation will not be confidential. However, data will be aggregated and presented generally across themes. We may use specific quotes if they help emphasize a common theme or offer a unique perspective. At the end of the interview I will ask if you are willing to have quotes attributed to you directly, or if you prefer not to have your name associated with your responses.

If you have questions about the project, you can contact the mentors for the project, Leah Dubots or Gina Eosco. I can provide their email addresses if you would like.

This interview is scheduled for 1 hour, but we can end early if you have any time constraints. Is there a specific time you need to finish by so I can make sure we cover everything?

Do I have permission to continue with the interview?

With your permission, I would like to record this session to ensure accuracy during analysis. I will use OtterAI to record the session and provide a transcript. Recordings and transcripts will be stored on a Google Drive that is accessible to the project members. Recordings and transcripts will be deleted at the end of the project, and no later than the end of the calendar year.

Do I have your permission to record the interview?