Model Issues and Forecasters' Requests - UFS MRW/S2S and SRW Applications (Final List from 2020-21 OSTI Forecasters Workshops)

Identified in the below table are the key issues raised by forecasters w.r.t. UFS MRW/S2S and SRW applications. Items on hurricane and air quality systems are not included here; they will be documented elsewhere.

	Focus area	Description of the issue / request	Target UFS Application	Comments
1	**Surface temperature and moisture**			
1a	Errors associated with low-level temperature inversions	This includes surface-based radiational cooling inversions, shallow cold air erosion and arctic fronts. GFS/GEFS struggle to properly decouple the surface layer in radiational cooling events, leading to very large 2-m temperature errors, even at very short forecast ranges. GFS historically struggles with timing the movement of cold air that moves south from Canada during US cold outbreaks east of the Rockies. There is also a tendency to 'erode' cold air too quickly when saturation (clouds) occurs in low level inversions on the back (west) side of surface high pressure. GFS struggles with making shallow cold air masses cold enough at the surface, most notable with cold air damming and with capturing the speed of cold fronts that are the leading edge of a shallow cold air mass.	MRW/S2S	This issue also impacts SRW. ICs and LBCs of SRW are driven by GFS/GEFS. Adjusting the PBL scheme itself will likely help, but coordinating this effort with NOAH-MP and land-surface data assimilation will be very important as well. Related areas: Coupling, PBL scheme, Land surface
1b	Errors associated with capping inversions	GFS struggles in the accurate representation of capping inversions. Overall, instability is often too low in the GFS, partially due to weak lapse rates aloft. (It has been made worse with the FV3 implementation). This is not a resolution issue since the 12-km NAM does a very good job with vertical profiles. Strength and height of capping inversions aloft affect a variety of sensible, high impact wx. (Handling Elevated Mixed Layer and stable layer at base of EML).	MRW/S2S	Many models struggle with representing capping inversions, but the GFS struggles worse than most other guidance. This issue also impacts SRW. Related areas: PBL
1c	CAPE issues	GFS had a long-standing low bias for CAPE that was made worse with GFSv15. Initial struggles seemed to be tied to weak lapse rates aloft; v15 introduced a late-day warm-season low-level cool, dry bias that seemed to worsen the low CAPE bias. GFSv16 over-mixes the PBL in the warm season (seemingly tied to dry soil), making the low bias even worse. Low CAPE does not appear to affect frequency of convection (resolved or parameterized)	MRW/S2S	The problem is worse in GFSv16 than in GFSv15, seemingly due to overmixing (connected to feedback from excessively dry soil). This issue also impacts SRW. Related areas: PBL, Coupling, Land surface
1d	Extreme heat index episodes	Extreme heat/heat index episodes underforecast by GFS in medium range.	MRW/S2S	This issue was prevalent in previous GFS versions. In the latest GFSv16 which is yet to be seen by the forecast community in summer months, there is initial evidence that new GFSv16 may have a high bias for extreme heat. Related areas: PBL, Coupling, Land initial conditions

		CAMs tend to be too cool in extreme western heat events, connected to the challenges of representing terrain-driven circulations and the marine layer	SRW	Land-type data sets are outdated and continued efforts to update them will lead to more representative coverage of urban areas
1e	Visibility, ceiling, clouds and fog	Prediction of onset and lifting of fog and low cloud cover associated with shallow cold air masses is a challenge. FV3 models have very little fog and low cloud cover.	MRW/S2S & SRW	Currently, forecasters continue to rely on post-processing techniques (e.g., LAMP) for the best forecasts of these parameters
		Ceilings in CAMs (especially HRRR) during precip events drop too low. Cloud information in CAMs is too binary; need more prediction of BKN and SCT cloud cover; CAMs predict too much IFR along the west coast in summer. CAMs can struggle to varying degrees with retaining shallow, cloudy airmasses	SRW	
1f	Temperature on complex terrain	Downslopes warming and/or drying often not captured well in global models (high RH bias)	MRW/S2S	As an example, this issue can lead to impacts that have fire weather forecast implications, esp behind drylines in the spring or early summer.
		CAMs struggle to generate and maintain convectively-induced cold pools of the proper magnitude and spatial extent - these features are critical to storm evolution.	SRW	First guess from the HRRR/NAM nest, etc., struggles to get the temperatures right for RTMA/URMA in areas of complex terrain
1g	Fire weather issues	CAMs tend to mix out low-level inversions too quickly with big implications for fire wx and air quality forecasting.	SRW	Model representation of the PBL mixing height/depth is critical for accurately forecasting fire weather conditions (surface RH and winds). Improved land DA can provide better initial conditions where surface conditions deviate from climatology; more model development needs to occur using single column models to understand and isolate the model biases. Capturing details of terrain-driven offshore flow and the marine boundary layer along the coast are critical to fire weather forecasting. Related Areas: PBL
1h	Temperature in general	Big challenges with forecasting differential heating and associated instability gradients, especially in areas with low cloud cover or cold pools	SRW, MRW/S2S	Main concern is how well the SRW modes handle these. However, GFS/GEFS (and all guidance) struggle with this too, but forecasters don't usually look to the coarser models to predict these gradients.
2	**Precipitation**			
2a	Precipitation type	Forecasts of precip type are poor, especially in and near transition zones.	MRW/S2S & SRW	Low-level temperature/moisture profiles are not correctly captured, leading to problems with p-type. (GFS struggles to represent the low-level temperature profile in warm advection winter precip events.) Key areas: PBL, Convection, Microphysics
		There is a huge need to output individual accumulations for each precipitation type (e.g. snow, sleet, freezing rain), including actual SLR-based snow accumulations, in all models.	MRW/S2S & SRW	Effort underway at EMC to address this in RRFSv1 and GFSv17/GEFSv13

2b	Precipitation rate	Scattered “popcorn” convection tends to produce precipitation amounts that are too high and cover too large of an area.	MRW/S2S & SRW	The shallow convection scheme needs to correctly represent the congestus phase to get the initiation of convection right, and to avoid the scattered popcorn convection. This is true even at convective scales, and doing this poorly could contribute to additional problems on day 2 and beyond. (The so-called pop-corn precip is mostly evident over mountains.) Popcorn convection in CAMs has a large wet bias, and it’s most prevalent in initial versions of FV3 CAMs. The problem is at least partially tied to to updrafts being too wide.
2c	Extended skill	Forecasters request convective skill beyond 48 hours and general precipitation skill beyond 1 week. SRW users desire more lead time for high-impact events, especially for IDSS purposes	MRW/S2S & SRW	The extended range skill comes from surface boundary conditions. A forecast system coupled from day one and also initialized with initial conditions produced with a coupled DA will provide better surface conditions for the large scale circulation and improved land surface properties. Extra forecast skills at the medium and S2S range can be achieved by improving tropical convection, stratosphere/troposphere interaction etc. Key areas: Coupling, Ocean, Land
2d	Extreme Precipitation events	It’s a huge challenge to capture high-impact, mesoscale flash flood events like both major floods in Ellicott City, MD.	SRW	Critical to accurately represent complex terrain, trade winds, and low-level convergence zones in Pacific Region, where there is limited CAM guidance
		There is a huge need to accurately capture the location and duration of mesoscale snow bands. The 90th percentile is not capturing the extreme QPF events in tropical and weakly-forced convective environment	SRW	
2e	Precipitation over complex terrain	CAMs still struggle a bit with orographic ratio and proper upslope/downslope QPF. CAMs can struggle with rain rates in features like Atmospheric Rivers, monsoonal convective cores and storm evolution over terrain.	SRW	
3	**Convection**			
3a	Convective Mode (Including supercells, multicells, MCSs and	Proper movement and propagation of MCSs is critical in the warm season for accurate forecasting of low-level temperature, moisture, and boundaries, which impacts next-day convection.	SRW (*MRW/S2S)	*The target application should be SRW, where resolution is fine enough to resolve aspects of thunderstorm dynamics. It would be useful for coarser models to accurately portray MCS characteristics as well to get warm season precipitation and down stream instability right.

	disorganized storms)			
3b	Convective Initiation	Dryline situations with isolated supercells produce minimal precipitation (spatially), but have a high conditional probability of severe storms. PBL overmixing during the warm season over the Plains results in a systematic eastward displacement of the dryline in the GFS. Accurate forecasts of dryline location is critical for severe weather prediction. The strength and height of the capping inversion (from the advection of elevated mixed layer) over the plains is not well represented by the GFS.	MRW/S2S	The vertical structure of temperature, moisture, and wind in the PBL (which impacts CAPE) prior to convective initiation is critical for forecasting thunderstorms and severe weather. GFS issues with CAPE are documented well in the previous section. Key areas: PBL
		Initiation, mode, intensity, evolution, precipitation, storm size) are a challenge for CAMs in weakly forced environments (warm season) and high-shear, low CAPE environments Many CAMs are late triggering convection, and once they do trigger, coverage can be too little. Several CAMs have a late-day, low-level cold bias that reduces instability and therefore intensity and coverage of deep convection.	SRW	CAMs have particular challenges when mid-level flow is weaker during summer. Subtle details in the BL influence the convective development in weakly-forced events. Making microphysics changes to improve representation of storm mode/evolution can sometimes negatively impact precipitation skill score
3c	Progressive shortwave troughs	Shortwave troughs are too progressive in the medium-to-extended range forecasts of the GFS/GEFS. This is a long-standing GFS issue. GFSv16 mitigates the bias partly, but there is still a need for improvement.	MRW/S2S	Troughs are well-resolved so diabatic heating may be the issue; Trough propagation could be tied to numerous factors: wave-surface stresses, gravity wave drag, PBL, all of which couple strongly to the dynamics; this is a difficult challenge that requires a holistic approach to model development. Key areas: PBL, Convection, Remote influence
3d	Thunderstorms in very short-range	Inaccurate depiction and evolution of thunderstorms in very short-range forecasts (0-6 h); storm-scale DA needed that includes accurate capture of ambient environment (as well as the storm)	SRW	
3e	Convectively induced cold pools	CAMs struggle to generate and maintain convectively-induced cold pools of the proper magnitude and spatial extent - these features are critical to storm evolution.	SRW	First guess from the HRRR/NAM nest, etc., struggles to get the temperatures right for RTMA/URMA in areas of complex terrain
4	**Winds**			
4a	Winds over complex terrain	Forecasters have concerns about how complex terrain causes upscale effects onto the synoptic pattern.	MRW/S2S	Need to understand and quantify the bias related to processes to fix the model issues. Product enhancement and METplus based verification.
		Forecast of downslope events is a concern	SRW	Stability and lapse rates plays a critical role in accurately forecasting downslope events NAM nest does a better job with downslope wind storms and inversion in complex terrain, and new RRFS needs to capture these “good” qualities.

		Coastal Jet details still not adequately portrayed, especially very near the complex coastline.	SRW	
4b	Winds over oceanic extratropical cyclones	Intensity (MSLP and wind speed) and track forecast up to 10 days is needed.	MRW/S2S	Need to consider developing datasets for extratropical cyclones similar to Best Track for tropical cyclones. Majority of improvement for TC is also applied to extratropical cyclones. Increase stratosphere-troposphere interactions and representation, tropical-extratropical interactions. Wind-wave and wave-wave interaction in extra-tropical cyclones. Tracking the extratropical system and database. Improved method for target observation. Key areas: Coupling, Marine Boundary Layer
5	**Tropical Cyclones**			
5a	Right-of-track bias	FV3 models have right-of-track bias for TCs.	MRW/S2S	This right-of-track bias for TC tracks in the GFS needs to be understood and addressed. HAFS focuses on special observations not assimilated in GFS yet. Have TCs in the right location, structure, and intensity in GFS. GFS will introduce more data such as all-sky radiance, recon data, more buoy data, commercial RO. Diagnose the processes to better understand, quantify and feedback the area for model improvement. Advance physics especially on microphysics, PBL, Radiation-cloud-aerosol interactions, and GWD to address the track bias, and synoptic waves propagation.
6	**Marine waves, winds and sea ice**			
6a	General - Sea Ice	There is a need to improve marine winds, waves, and sea ice prediction guidance to address vessel voyages and route planning from weather to climate timescales. This includes the ocean as well as Great Lakes domains.	MRW/S2S	Also connected to errors associated with inversions in the Marine Boundary Layer and coupling. Key areas: Sea ice, Coupling, Marine Boundary Layer
7	**Space Weather**			
7a	General - Space weather	Models and data assimilation systems currently in use are generally immature. Focused applied research on operational forecast needs lacks within the broader space weather research community.	Space Weather	Transitioning of the GFS based WAM into the UFS and development of data assimilation for the UFS version of that model is also of interest to the community.