Afternoon Breakout Discussions

Clubs (♣)

Petar Bukovcic, Gang Chen, Alex Fierro, Thomas Jones, Pierre Kirstetter, Swapan Mallick, Greg McFarquhar, Berry Wen, Nusrat Yussouf, Guifu Zhang

Scribe: Thomas Jones

How can *radar retrievals, in-situ measurements, data assimilation and models* with different scales be used in an optimum way to reduce uncertainties in forecasts, and what is the best mechanism for establishing uncertainties in predicted variables?

- Need better methods for quantifying model and observation uncertainties.

- What these methods are is an open question!

- Model forward operator errors (uncertainties) compared to observation error (uncertainties) may not be consistent.

- Extract information content from remote sensing data (radar, satellite, etc). Using the right data to sample specific atmospheric properties.

• Determine what parameters in microphysics schemes are adjustable and what the appropriate range of adjustment is.

• Find more ways to gather in-cloud observations for use in verification. More field campaigns?

• Formalize uncertainties using probabilistic methods.

• Physically based stochastic modelling.

What is hindering progress from being made on improving atmospheric predictability?

- Lack of boundary layer observations (T, Q, wind, cloud base?, PBL depth?)

- Use indirect information from existing radar network to get something? Under development.

- Satellite hyperspectral sensors good for mid-to upper level T / Q measurements, not for PBL. Also, no geostationary hyperspectral sensor UASs in the future?

- Precipitation phase observations (radar and satellite can help).

- Balance between a small number of “high quality” observations and a larger number of “lower quality” observations. Need both.

- Non-Gaussian observation error characteristics

- Assumptions in model parameterizations.

- Lack of collaboration between the observational and modelling communities (radar and satellite in particular). Have people whose primary job is to facilitate collaborations ($$$).

What are the key sources of uncertainties, and how can they be reduced or minimized?

- Model parameterizations: boundary layer, and cloud microphysics schemes.

- Relationship between radar observation and derived radar observations from the model state.

- No set of parameterizations and schemes can fully account for the variability of the atmosphere.

- Observation and model forward operator biases and uncertainties. What are the correct bias adjustments and should they even be applied? Understand the physics behind the biases to generate physically based bias corrections.

- Observation quality control and consistency of quality control among different observation types. Lack of true ground truth

- Minimize uncertainty or learn how to use uncertainty in the forecasting process?

What additional tools, models, observations and resources need to be brought to the problem to address these challenges?

- Increased use of dual-pol radar variables and derived products (ice water content) to reduce analysis errors and uncertainties.
- Sensitivity studies to assess observation impacts (especially for storm-scale). Use scale specific verification metrics.
- Further assessment of quality control of observation to be assimilated. Are we leaving out good observations?
- Increasing observations of convective cores (the old T-28 / A-10 missions).
- Reach out to experts in the numerical tools used in data assimilation.
- Better assessment of model behavior relative to both assimilated and non-assimilated observations
- Increased people and high-performance computing resources.

Are more data sets needed? Are new analysis techniques needed?

- Yes. More in-situ and remote sensing data needed.
- Observations across all spatial and temporal scales.
- Range defined quasi vertical profiles. (BL profiles from WSR-88D radars).
- More understanding of exactly how remote-sensing observations relate to atmospheric variables (especially Q).
- Various model analysis techniques are out there, all with advantages and disadvantages. Further refinement of these techniques is needed
- Tune analysis techniques to use as many observations as possible. What works correctly in models and what doesn't.

What are the biggest priorities?

- Need to improve model and observations synergistically, but keep in mind potential uncertainties

- Better utilization of currently available observations / tools.

- Bridging the gap between observations and models.

- Increased interdisciplinary collaboration, requires funding and a time commitment across multiple groups.

- Need more computer programing experience in students in early-career scientists.

Conclusions

- More collaboration between observations and modeling/DA community.
- Reach out to mathematicians who are experts regarding how we formalize the problems
- Utilization of existing observations (Dual-pol, BL from WSR-88D, etc).
- Minimize uncertainty or learn how to use uncertainty in the forecasting process?