Selecting Metrics for Specific Applications

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Validation and metrics

- Validation
  - Making sure that the product (model and/or data) is accurate
    - Goal is to improve the model!
  - Ideally should compare with many different sources to makes sure that the model is accurate in all states
    - Model right for the wrong reason?
  - Could be event analysis or statistical
  - Could be with any data set that will help to improve the model
- Metrics
  - Track the improvement in the model performance over time
    - Goal is NOT to improve the model but to simply track the improvements that are made over time
  - The comparison should stay the same for consistency
    - Same types of data sets
    - Same types of model runs (prediction vs historical)
    - Independent organization should test the model “out of the box”
  - Goal isn’t to “beat” other models
    - With funding levels in the toilet, this is hard to keep in mind.

Metrics, practically

- Metrics should be related to what operators want more than what might help modelers improve their codes
  - Validation is for code improvements
- Metric studies (not challenges!) should be conducted on a regular schedule
  - Latest models should be provided to independent entity
  - Runs should be done and made public
  - Results should be added to a database and the changes in performance should be plotted and displayed
- Modelers should not really care too much about the results for a given time, since the trend is much more important
  - This is difficult for a modeler to do

Metrics, specifically

- Thermosphere
  - The mass density is important for predicting the satellite drag environment.
  - Science satellites (CHAMP, GRACE, GOCE, and Swarm) can measure the acceleration of the satellite and can back out the mass density (ignoring the in-track wind).
    - Can get “high resolution” density maps
    - How long will this continue?
  - Department of Defense tracks spheres to determine mass density over many orbits
    - Quite low resolution
    - Does this matter for operations? (Can determine bias in the models)
  - Recommendation:
    - Orbit averaged mass density (could be corrected for wind effects)

Metrics, specifically

- Ionosphere
  - The ionospheric density and structure is quite important
  - Total electron content and scintillation determination can help to address this
    - Does not really address radio propagation effects, but improvement in TEC prediction would (hopefully) lead to improvement in electron density specification
  - GPS data is available over the US and in South America (near the magnetic equator)
  - Recommendation:
    - Total electron content maps over the US and South America
    - Include stations that may be encountering scintillation

Metrics, specifically

- Inner magnetosphere
  - Spacecraft charging and radiation effects are important
  - What satellites actually provide a full distribution function of electrons?
    - LANL is the longest running group, but there are issues with getting the data consistently
    - Van Allen Probes – but these won't last forever
  - Recommendation:
    - Distribution functions (or fits to those functions? Or total flux in certain energy bins?) of the electrons along the LANL satellite tracks

Metrics, specifically

- Outer magnetosphere
  - Magnetic perturbations are available from a wide variety of sources.
  - What do perturbation tell us:
    - Bulk perturbations on the ground indicate strength of currents into the ionosphere
    - Perturbations at geosynchronous orbit shows stretching in the tail
    - dB/dt is important for electric grid
    - While magnetic perturbations don't show how well the codes are doing in terms of densities and velocities, the perturbations are a result of these things.
  - Recommendation:
    - Magnetic perturbations at a variety of sites on the ground (both bulk perturbation and dB/dt)
    - Magnetic perturbations at geosynchronous orbit (GOES)

Metrics, specifically

- Heliosphere
  - Obviously, heliospheric data products drive the magnetosphere, ionosphere and thermosphere models.
  - We will most likely have a continuous monitor at L1 for a long time to come.
  - Recommendation:
    - Solar wind density, velocity and temperature as well as interplanetary magnetic field at L1 spacecraft.

Metrics, specifically

- Corona:
  - I don't know very much about the sun (we don't see it very often in Michigan…)
  - Seems like important things are:
    - Locations of the active regions
    - Strength of the magnetic field and flow speeds
    - When flares and CMEs occur
  - I am not sure what measurements could be used for metrics
  - Obvious choice would be timing of flares and CMEs

Quite vs Storm

- The metrics are really going to be different as a function of activity level.
  - Some models may have no bias, but maybe won't be able to predict the large storms.
  - Some models may be able to get the storms better, but have a large bias, so they are often "incorrect" in absolute numbers.
- Each metrics run should both active and quite conditions in them in order to track how models are doing in both regards.
  - Could simply be running a two week periods, in which the second week is a storm or something.
  - Quite metrics and active metrics are tracked separately.
    - For geospace, can differentiate by a Dst of -50 nT.
    - With enough results, the metrics as a function of activity level can be determined.

Summary

- Metrics and Validation are different
  - CCMC should really be concentrating on metrics
- Thermosphere – mass density at different satellites/objects
- Ionosphere – TEC/Scintillation over US
- Inner magnetosphere – Electron energy spectra at geosynchronous satellites
- Outer magnetosphere – Magnetic field at ground-based magnetometer sites and geosynchronous orbit
- Heliosphere – IMF and SW at L1
- Corona – Timing of flares/CMEs
- Storms vs non-storms – Keep track of both