“Real-Time” IRI Task Force

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Two Related but Distinct Objectives

- Transition from IRI climatological reference model to an ionospheric weather model
  - Provide a record of the state of the ionosphere
  - IRI re-analysis - equivalent to NCAR re-analysis
  - Post-processing, not necessarily real-time

- Real-time characterization of the ionosphere for operational use
  - Several centers now producing real-time regional or global ionospheric maps, TEC, NmF2, 3-D electron density: US-TEC, AFWA/GAIM, JPL-GIM, COST/Europe, ….

Motivation

- Provide continuous dataset of ionospheric weather to the community for science studies
- Space weather application
- Increase in availability of data
- Development of data assimilation techniques in our discipline
- Increasingly closer connection between meteorology (terrestrial weather) and space weather

Related Activities

- IGS TEC maps and weighted mean, 2 hour time resolution (CODE, ESA, JPL, UPC) latency: “rapid maps” < 24hrs, final ~11 days
- SCINDA - real-time estimates of ionospheric irregularities

Questions/comments:

- How important is the real-time aspect vs improved historical weather characterization, do we want to do both
  - IGS vs SWPC scenarios
- For reanalysis how far back in time should we go
- How often should we re-do analysis
- Multiple methodologies and maps
- Fixed methodologies over analysis period
- Can learn from meteorology
- LWS focus topic for US funding (similar to COST)
- Other agency funding

Q1: Data assimilation technique

- Kalman filter
- Ensemble Kalman filter
- 3-D/4-D variational techniques
- Forward model -
  - Gauss-Markov, relaxing to climatology (IRI)
  - Physics based model

Q2: Design

- Vertical structure EOFs, grid point, parametric b_0, b_1, etc.
- Spatial resolution
- Spectral or grid point
- Mapping techniques
- Temporal resolution
- Regional, multi-regional, or global
- Which parameters should we initially focus on: NmF2, hmF2, TEC, 3-D N_e, ΔN_e…..
- Uncertainty maps
- Is the IRI structure sufficiently flexible to characterize "unusual events" - F3, SEDs, large OSEC

Q3: Where

- Should this be an IRI activity
- What should be involvement of ISES and operations center e.g. SWPC
- Collaborations/partnerships: what is connection to IGS, ICG activities
- Where should it be done - one centralized co-ordinated activity or a distributed activity
- Who should coordinate activity
- Is this the right time

Q4: Data sources

- Ionosondes (30), Radio occultation (3000/day COSMIC, CHAMP, SWARM, etc), ground-based GPS/GNSS (~2000), imaging, in-situ satellite, etc.
- Neutral atmosphere O/N2, density, etc.
- Data quality
- Centralized co-ordinated database, where
- Issues in data sparse regions
- Impact of new data sources on trends

Q5: Validation

- Evaluation criteria
- Metrics
- Validation data
- Average of ensemble runs
- Residuals - difference between analysis and data
- Differences in analysis with and without new data source

The way forward

- Hear about past activities in this area
- Hear about new methodologies
- Evaluate if we should pursue one or both of these activities
- If yes, begin to address some of the previous questions

IRI Weather: proposed study

- Retrospective analysis initially (real-time to follow)
- Assimilate data to produce multi-regional analysis over Europe, CONUS, Australia, South America….others?
- Parameters: 2-D NmF2, hmF2, and TEC initially plus uncertainty (gradually move to 3-D structure, plus other parameters)
- Spatial resolution: 1°x1° or 2°x2° or technique dependent ??
- Temporal resolution: 15 mins ??
- Data sources: ionosondes and GPS ground-based initially (gradually adopt additional datasets after careful evaluation of their impact on the analysis)
- Nominate a data coordinator for each region: CONUS (Eduardo), Europe (Anna), Australia (Garth), South America (Michael S.)

IRI Weather: proposed study (cont)

- Data coordinators will assemble database of selected intervals for use by all the analysis groups
- Each analysis group creates the maps over all regions using their preferred mapping technique, using IRI for the background model or for gradients etc.
- Retrospective analysis for selected periods:
  - Include quiet and storm intervals
  - Extended periods ~1 month, Jan 2005, equinox period
- Perform validation using internal methods
- Hold back data from the analysis for validation
- Agree upon metrics to estimate uncertainty in analysis
- Dieter to apply metrics to analyses

IRI Weather: proposed study (cont)

- Meet again to compare results next year as Task Force or as part of the Bremen COSPAR IRI Workshop, July 2010,
- At the meeting decide on a way to combine the analyses (e.g. IGS ensemble) or decide on a common technique, and run for an extended period ~ 1 year over all the regions
- Make analysis available on IRI web page for science studies
- Test in real-time
- Gradually improve on the techniques and apply to the previous 5 year period and make available to community
- Combine regions to produce global high-resolution analysis
- Introduce 3-D/vertical structure and other parameters
- Determine the impact of new data sources e.g radio occultation

IRI Weather: open discussion

- Focus areas: Europe, North America, (choose 200 stations for assimilation), global (choose 500 stations including IGS) (regions chosen because of dense data sources, number of ionosondes, number of g-b GPS, etc)
- Trevor Garner to coordinate global GPS datasets (RINEX)
- Ivan Galkin to coordinate global ionosonde datasets
- Regional data coordinators:
  - Europe, Anna, DIAS datasets etc, (ionosondes hand or auto-scaled?)
  - North America, Eduardo
- Future regions: e.g. South Africa, Australasia, South America
- Where to assemble data, central or regional databases
- Spatial (minimum 2x2) and temporal (min 15 mins) resolution
- Intervals (Jan 2005, Oct 15th - Nov 15th 2003)
- Metrics (differential for TEC, NmF2 and hmF2, bias, SD, RMSE)
- Next meeting, Lowell Oct 2010, encourage also present at COSPAR