Developing a Space Weather Verification System Using METplus

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2020 International Workshop on Verification Methods
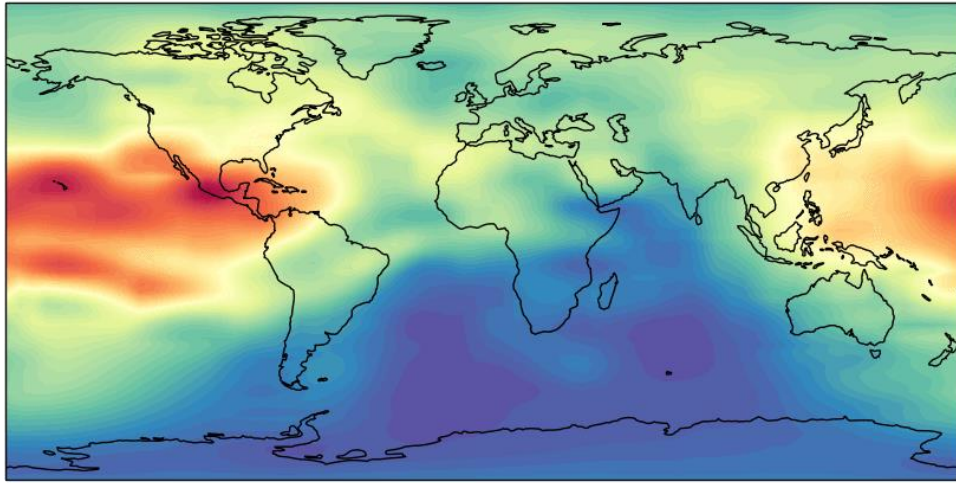*1600 UTC   17 November 2020*

Introduction

- Key drivers of space weather:
  - Solar wind
  - Solar flares and radiation storms
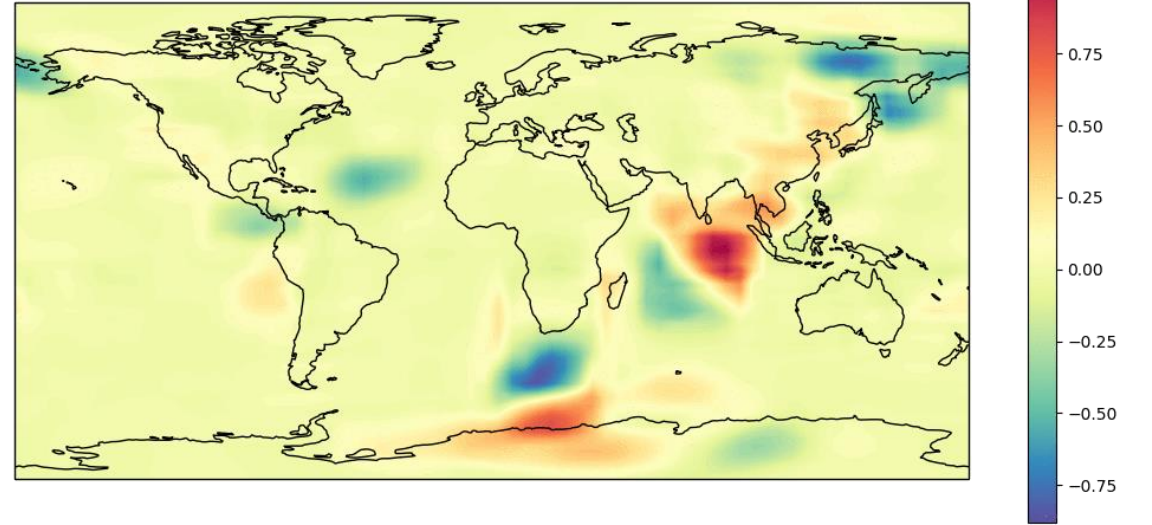 - Geomagnetic field and activity indices
  - Total Electron Content (TEC)

Goal of this work: create a real-time evaluation system for NOAA's Space Weather Prediction Center
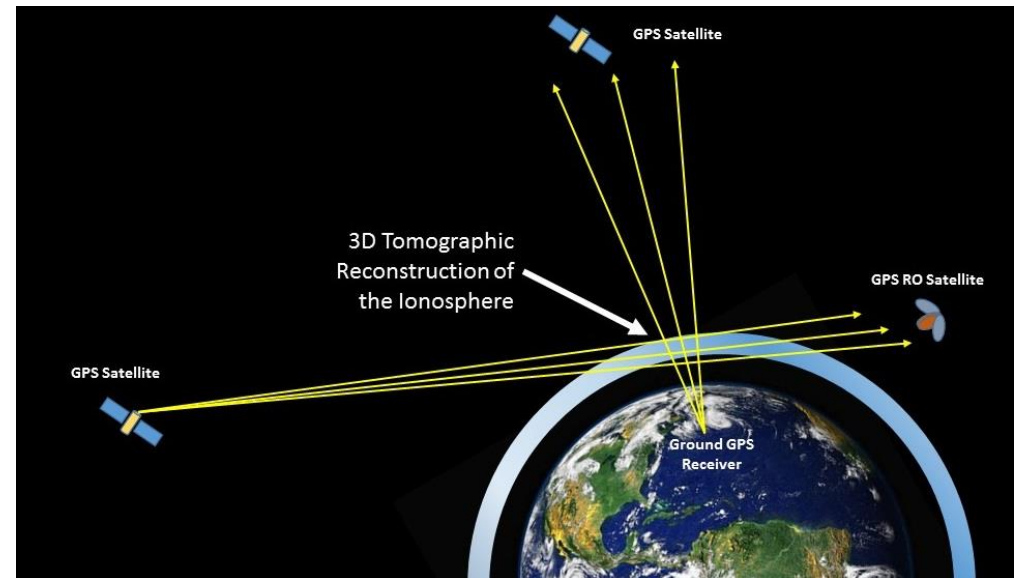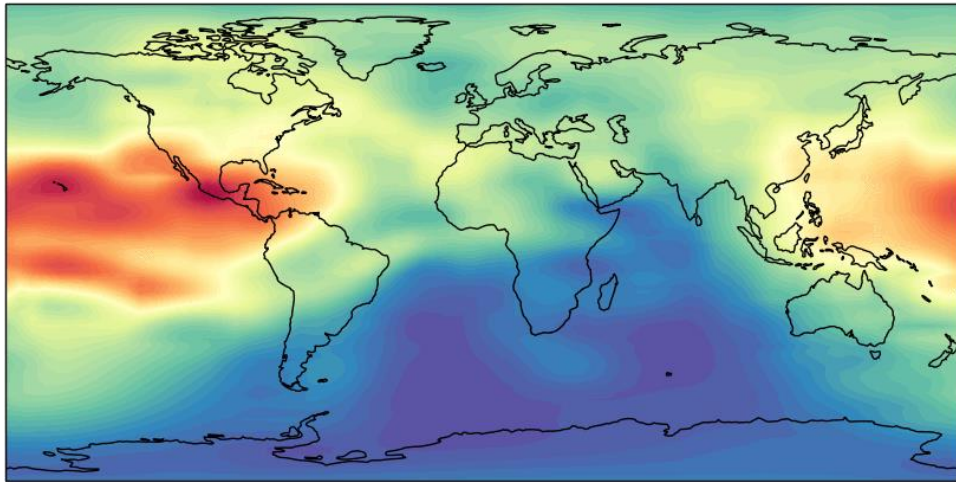
GloTEC With and Without COSMIC RO



Courtesy of Rodney Viereck, NOAA SWPC

Models, data, formats, variables

- Global Total Electron Content (GloTEC)
  - Combines ground-based and space-based (COSMIC) GPS/GNSS observations to create a 3D assimilative map of the ionosphere
  - Provides specification to many users including GPS/GNSS and satellite communications

- Whole Atmosphere Model (WAM) coupled with the Ionosphere Plasmasphere Electrodynamics (IPE) - WAM-IPE
  - Extension of GFS up to 600 km with one-way coupling to the ionosphere
  - Imparts terrestrial weather effects (waves, solar tides, etc.) to the ionosphere

- Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model (CTIPe) model
  - A model that runs ~30 minutes ahead of real-time based on Advanced Composition Explorer (ACE) measurements
  - Has the potential to forecast the state of the thermosphere/ionosphere system, including TEC variability.

Key variables and challenges

- Key variables:
  - vertical TEC (vTEC)
  - electron density profiles

- Challenges and opportunities
  - Non-compliant data formats
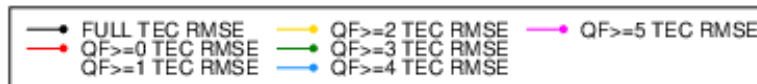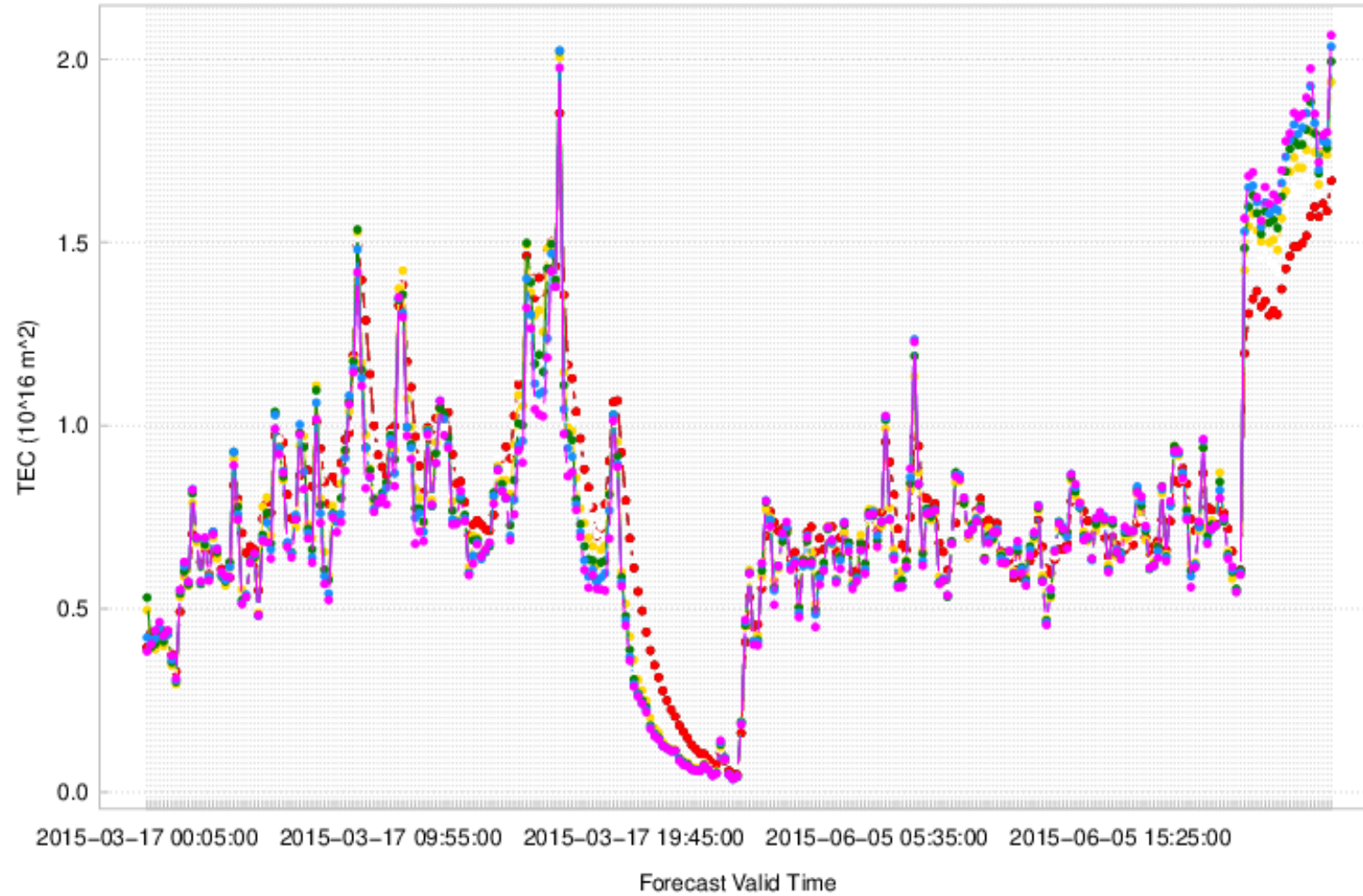 - New units
  - Masking requirements
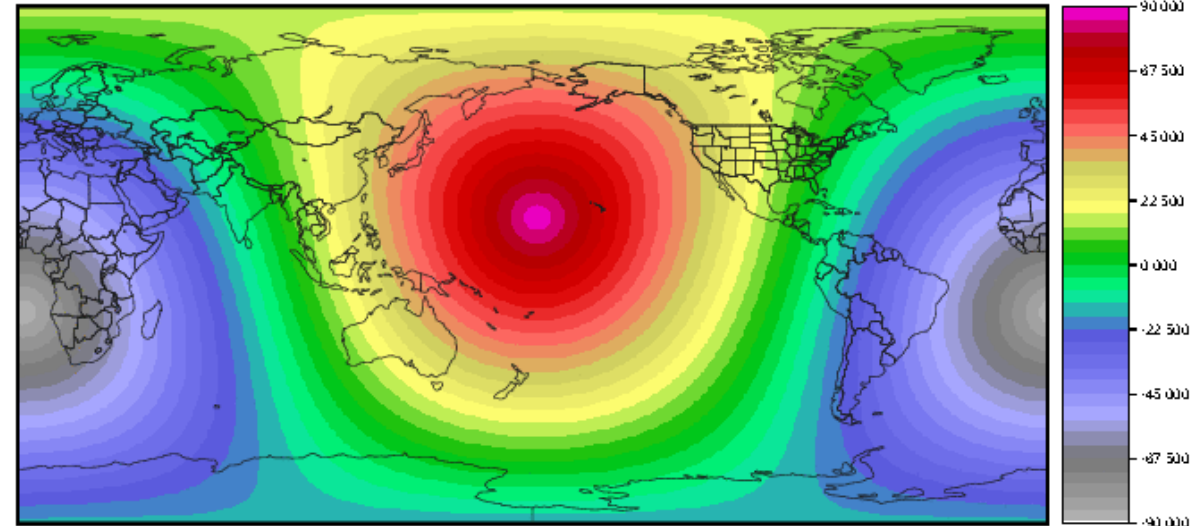
solar_alt_00.nc
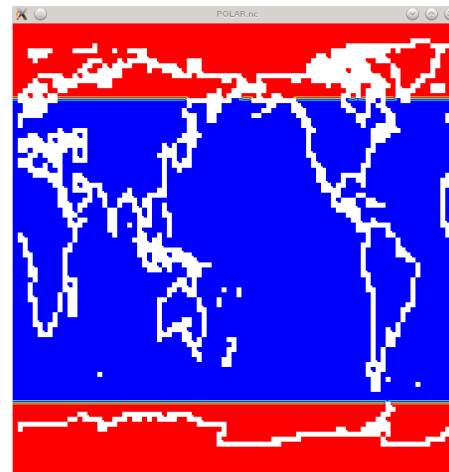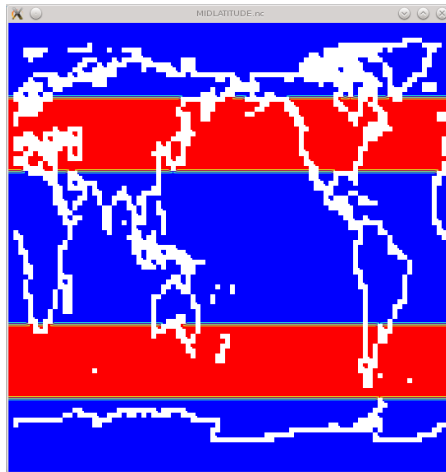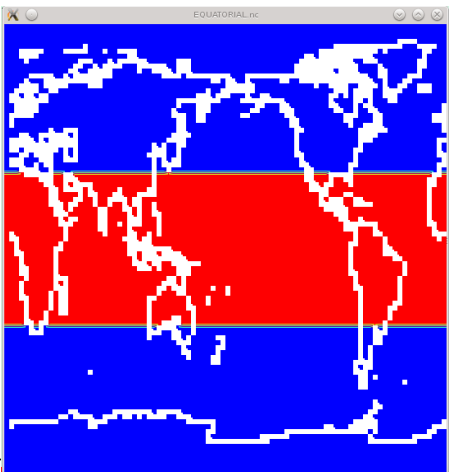
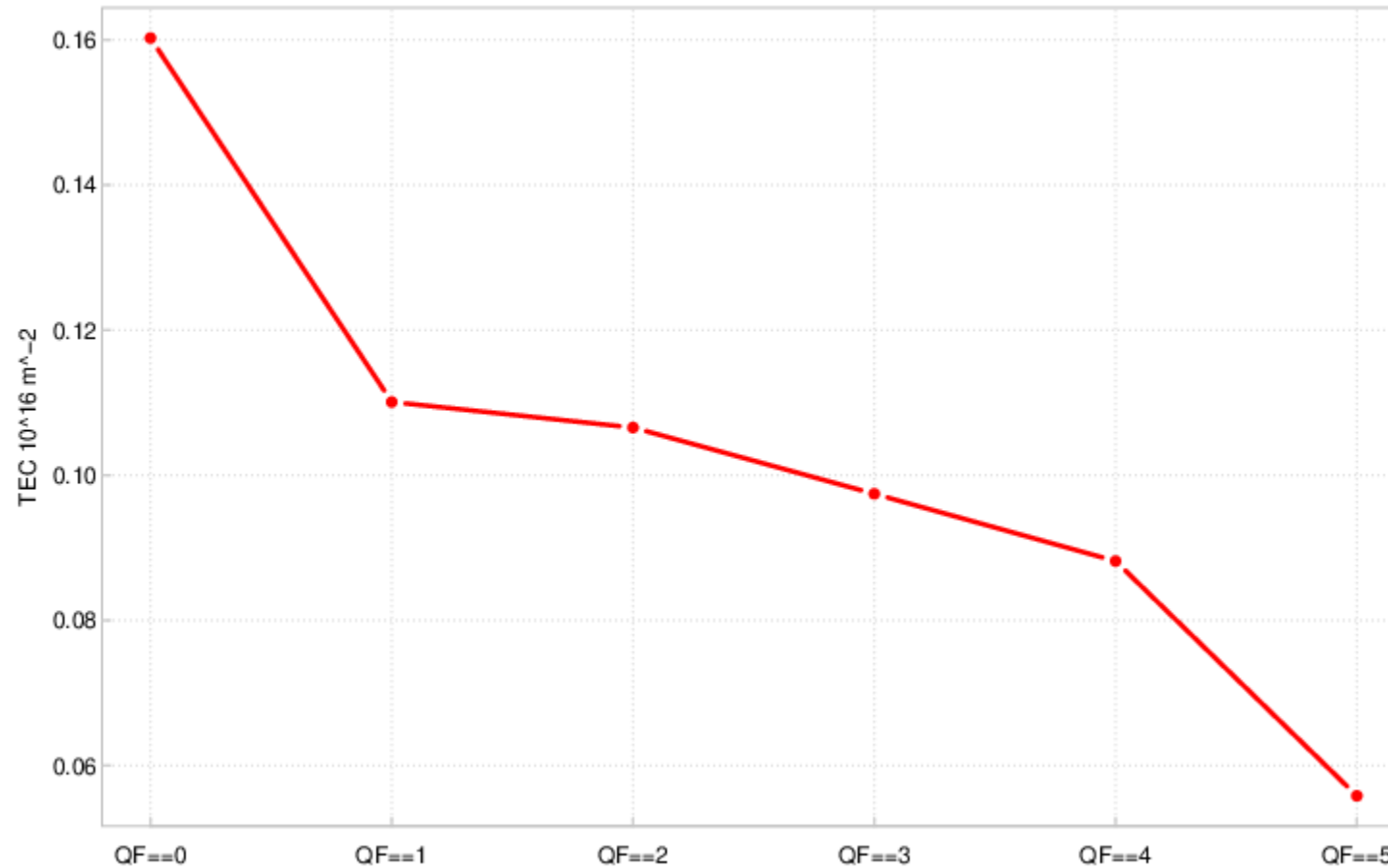# Example of time-depending QC masking

GloTEC w/COSMIC vs. w/o – RMSE

Example: Data Density Flag Masking
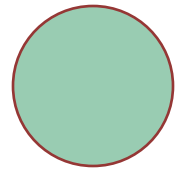
Difference in TEC without and with RO
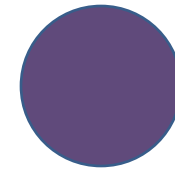

More difference in data sparse regions

Less difference when ground-based observations available

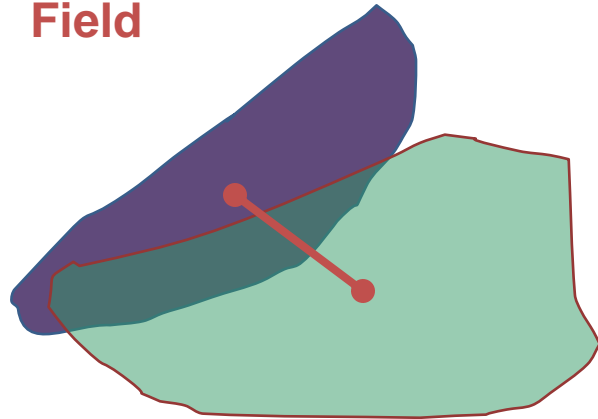QF = number of voxel's passing through a grid point

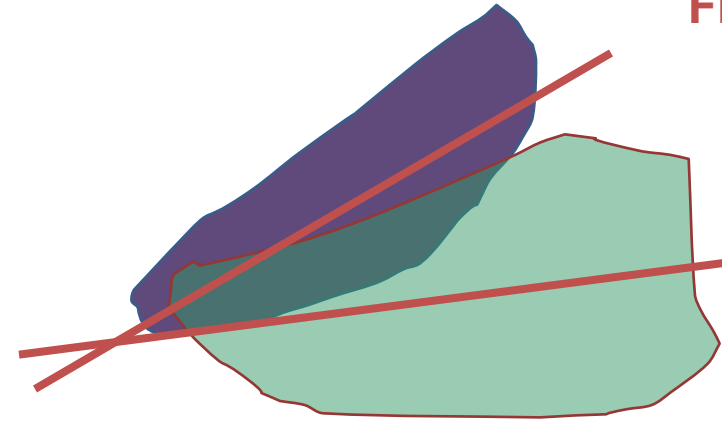Use of Pair Attributes defined by MODE

Forecast Field
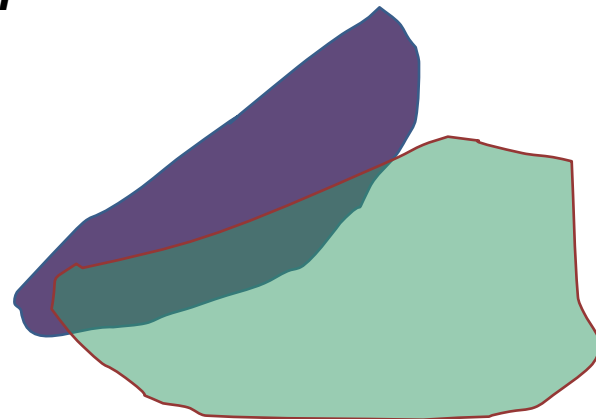
Analysis Field

Centroid Distance: Provides a quantitative sense of spatial displacement of forecast.
0 is optimal

Axis Angle: For non-circular objects – gives measure of orientation errors.
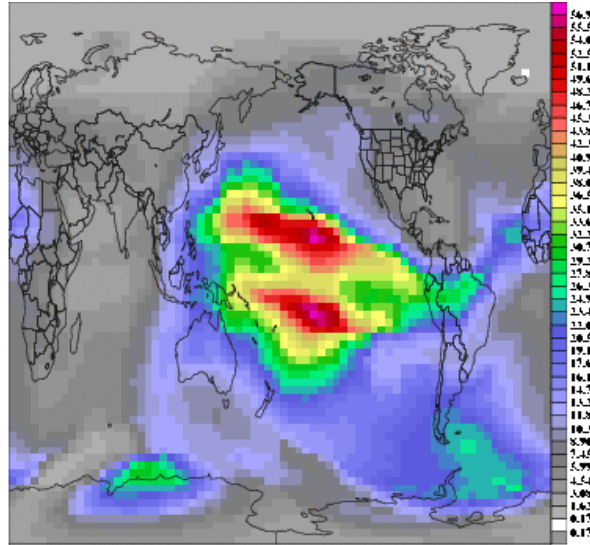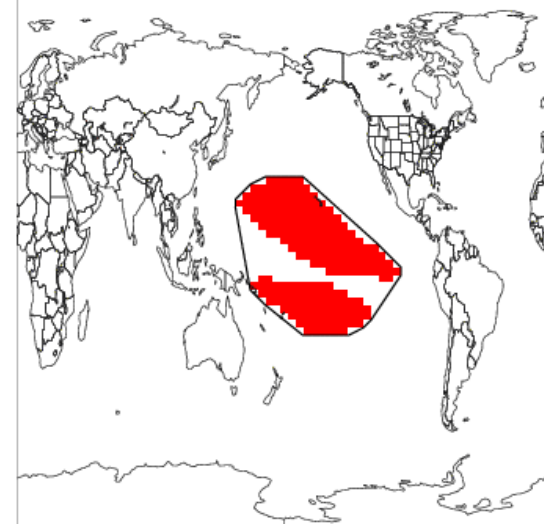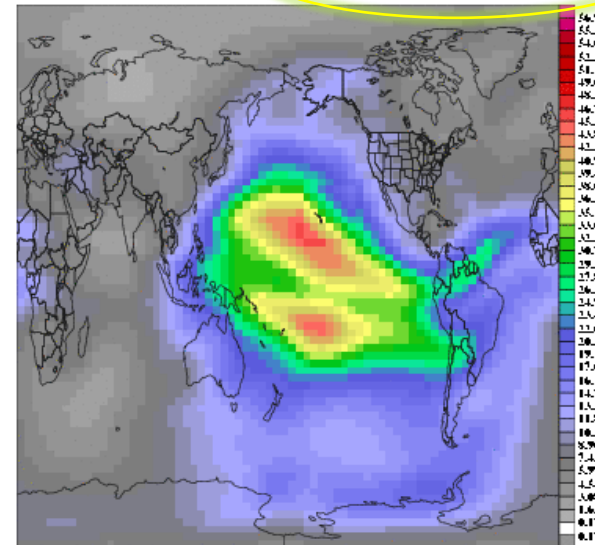*0 is optimal*

Area Ratio =
F Area
A Area

Area Ratio: Provides an objective measure of whether there is an over- or under-prediction of areal extent of forecast.
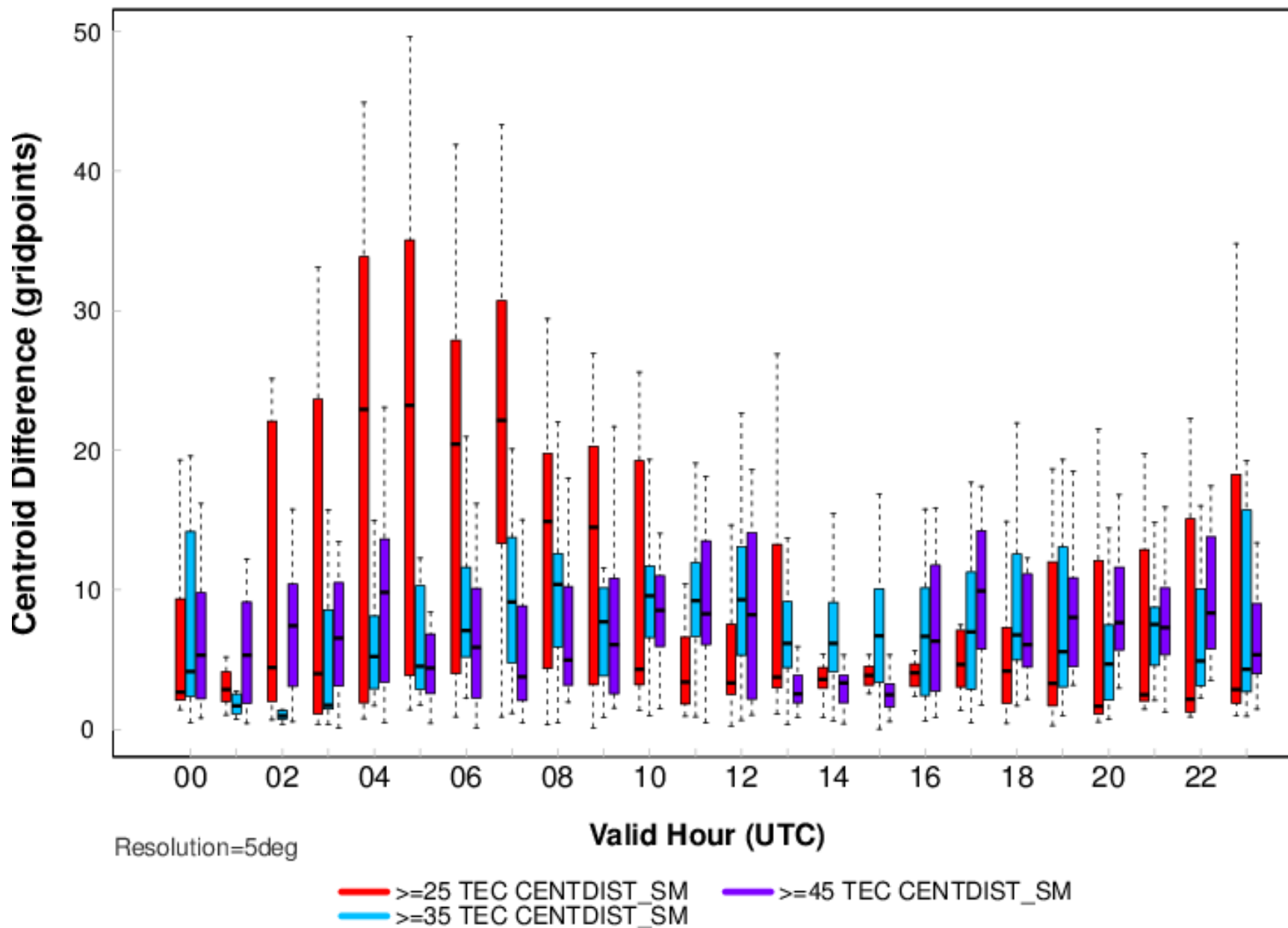*1 is optimal*

MET Tool: MODE

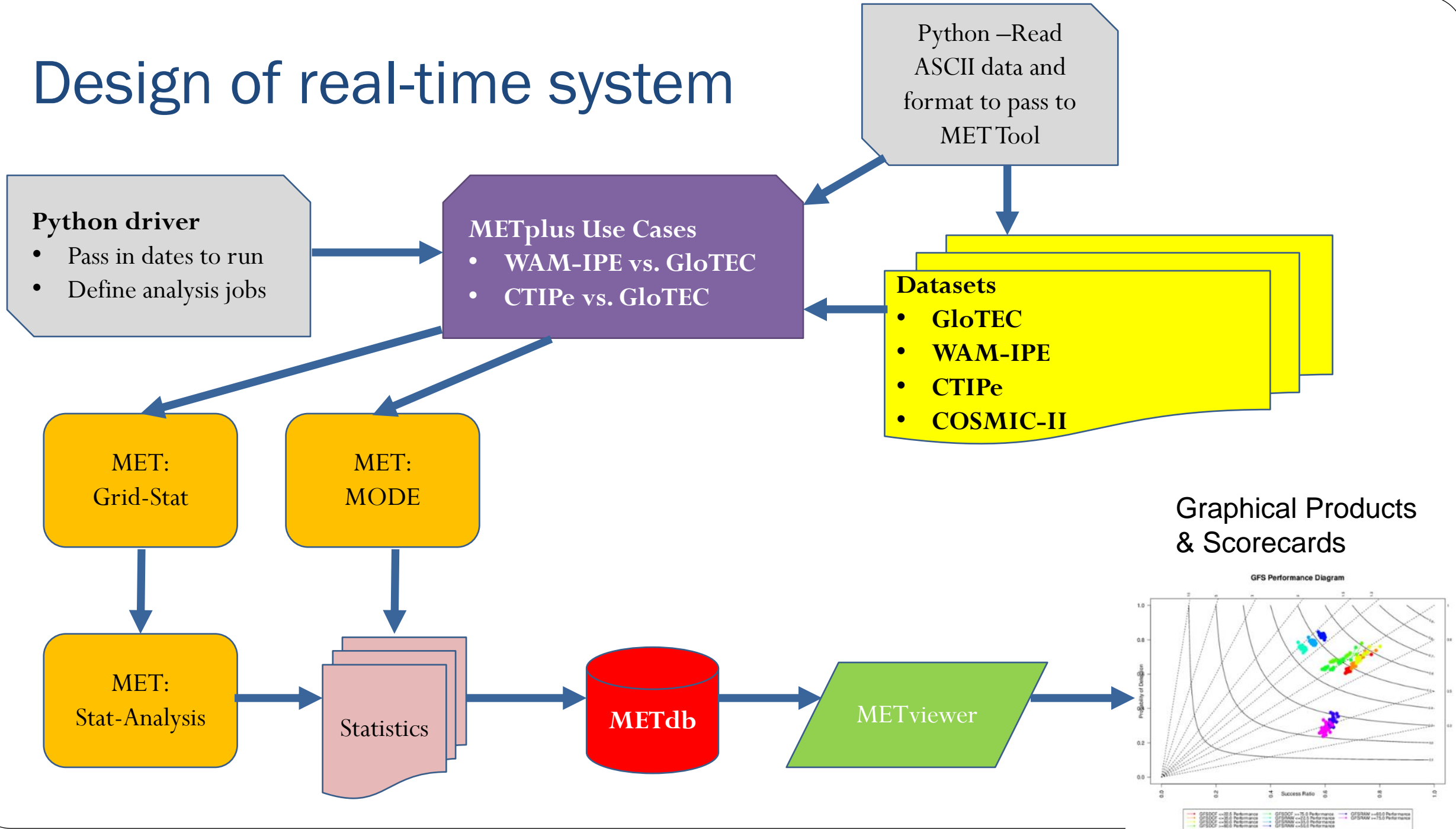WAM-IPE >45 TECunits

GloTEC >35 TECunits

WAM-IPE bias confirmed by other more traditional statistics over several cases

This information was fed back to SWPC developers who were able to made adjustments

WAM–IPE MODE Centroid Difference – Hourly – Matched Only

Centroid Difference (gridpoints) vs Valid Hour (UTC)

Resolution=5deg

Legend:
- >=25 TEC CENTDIST_SM (red)
- >=35 TEC CENTDIST_SM (cyan)
- >=45 TEC CENTDIST_SM (purple)

Design of real-time system

Questions

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