HIWPP Goals

- Accelerate NOAA/US global model development
- Hydrostatic model 3.1 sub-task goals:
  - Establish "advanced hydrostatic model" **benchmark** by which to measure performance of upcoming global non-hydrostatic models
  - Improve hydrostatic-scale medium-range forecast capability via advanced models and ensembles
  - Improve components (physics, DA) applicable also to non-hydrostatic models

Components of HIWPP Hydrostatic Model Methodology

- Development
  - Data assimilation
  - Ensemble forecasts
  - Physical parameterizations and hydrostatic models
- Verification and evaluation
  - Retrospective testing
    - Provides baseline skill for GFS, NAVGEM, FIM models
    - Modifications to parameterizations, DA, numerics
    - Multi-model ensembles (e.g., GFS and FIM) for possible NAEFS extensions
  - Quasi-real-time testing
    - Advanced higher-resolution deterministic runs
    - Experimental NAEFS and GEFS extensions (addition of ~10 members each from FIM and NAVGEM)

Ensemble forecasts for HIWPP hydrostatic models/ensembles

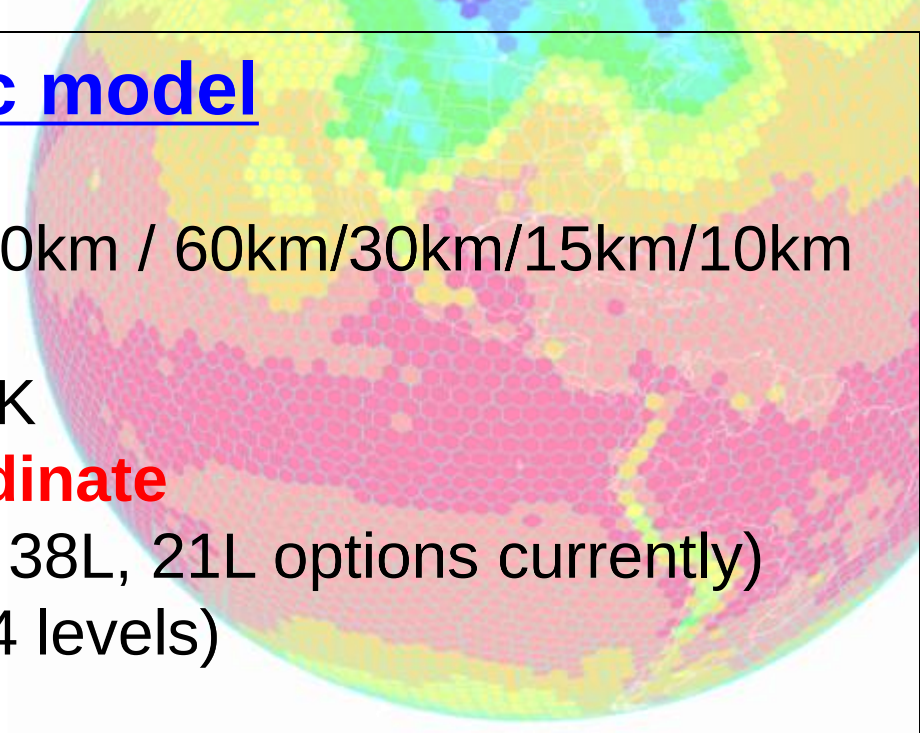
- Experimental extension to NAEFS
  - Add ~10 members each of FIM and NAVGEM at highest resolution possible to GEFS/NCEP (and CMC)
  - Can value be added to current NAEFS (GEFS + CMC)?
  - Can value be added to GEFS with multi-model approach (with FIM replacing some GEFS members at same CPU cost)?
- High-resolution mini-ensemble from HIWPP deterministic models
  - ~3-member ensemble at up to ~15km resolution – GFS, FIM, NAVGEM
  - Is value added with this mini-ensemble?

HIWPP 3.1 – hydrostatic modeling - components

- 3.1.1 - assimilation/ensembles/stochastic physics
  - - Jeff Whitaker and Tom Hamill
- 3.1.2 - parameterization development
  - Georg Grell and Tom Hamill
- 3.1.3 - GFS and global ensemble/NAEFS –
  - Yuejian Zhu
- 3.1.4 – FIM
  - Stan Benjamin
- 3.1.5 - Navy –
  - Melinda Peng and Tim Whitcomb

HIWPP hydrostatic global model contributors

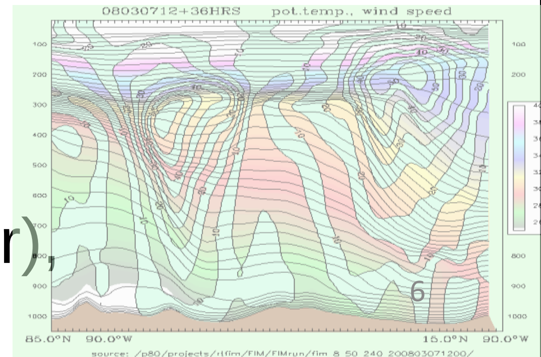
	Horizontal resolution	Lab	physics	Vertical grid	Horizontal representati on
GFS	T1534, 13km	NCEP/EMC	GFS physics	Sigma	spectral
FIM	15km, 30km	ESRL	GFS physics	ALE (hybrid isentropic-sigma	icosahedral
NAVGEM	21km	NRL	NRL	Sigma	spectral



FIM numerical atmospheric model

- Horizontal grid
  - **Icosahedral,** Δx=240km/120km / 60km/30km/15km/10km
- Vertical grid
  - ptop = 0.5 hPa, θtop ~2200K
  - **Generalized vertical coordinate**
    - **Hybrid θ-σ** option (64L, 38L, 21L options currently)
    - **GFS-like σ-p option** (64 levels)

- NEMS-compliant (part of FIM test suite applied to all commits)
- Physics
  - GFS physics suite: 2015 (incl. EDMF PBL), 2011 versions
  - Option for Grell-Freitas scale-aware deep/shallow cumulus
  - Option for other WRF parameterizations
- Coupled model extensions
  - Chem – WRF-chem/GOCART
  - Ocean – icosahedral HYCOM (no coupler), tri-polar HYCOM (with coupler)

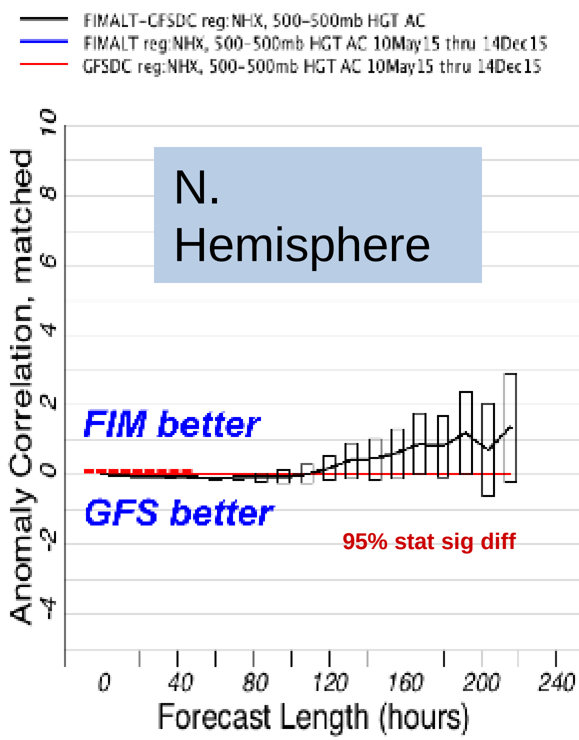


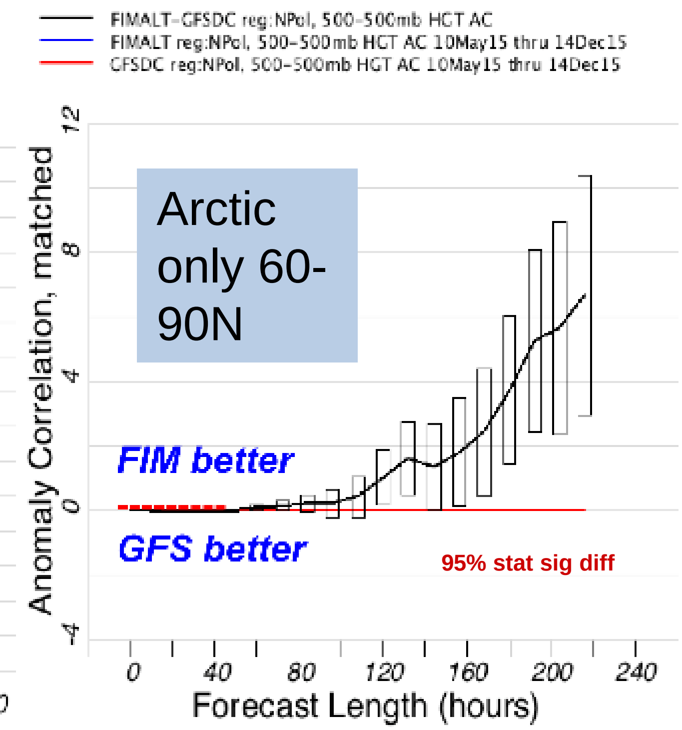
500-hPa Height Anomaly Correlation FIM-30km (GFS init, GFS phys) vs. GFS NCEP operational

May-Dec 2015

FIM-30km real-time vs. GFS operational – T1534
- FIM using GFS physics, GFS initial conditions.

0-9-day forecast – May-Dec 2015
95% significance bracket shown





Effect of alternative dynamic core (icosahedral, isentropic) from FIM

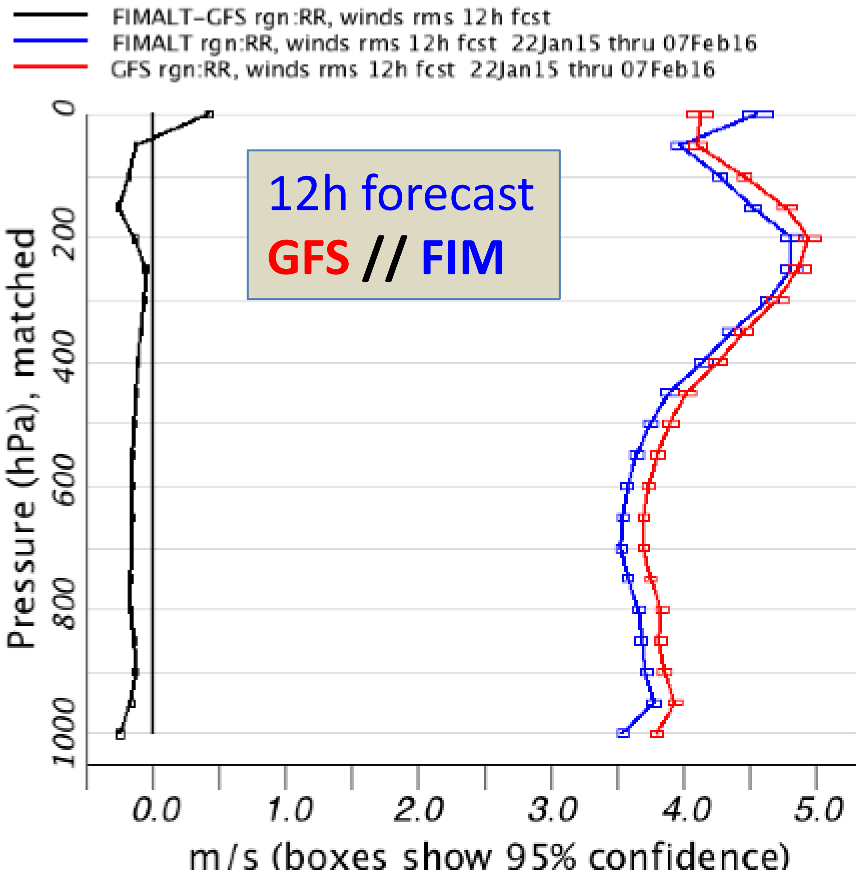
Wind RMS error vs. raobs N. America

GFS (T1534) // FIM-30km

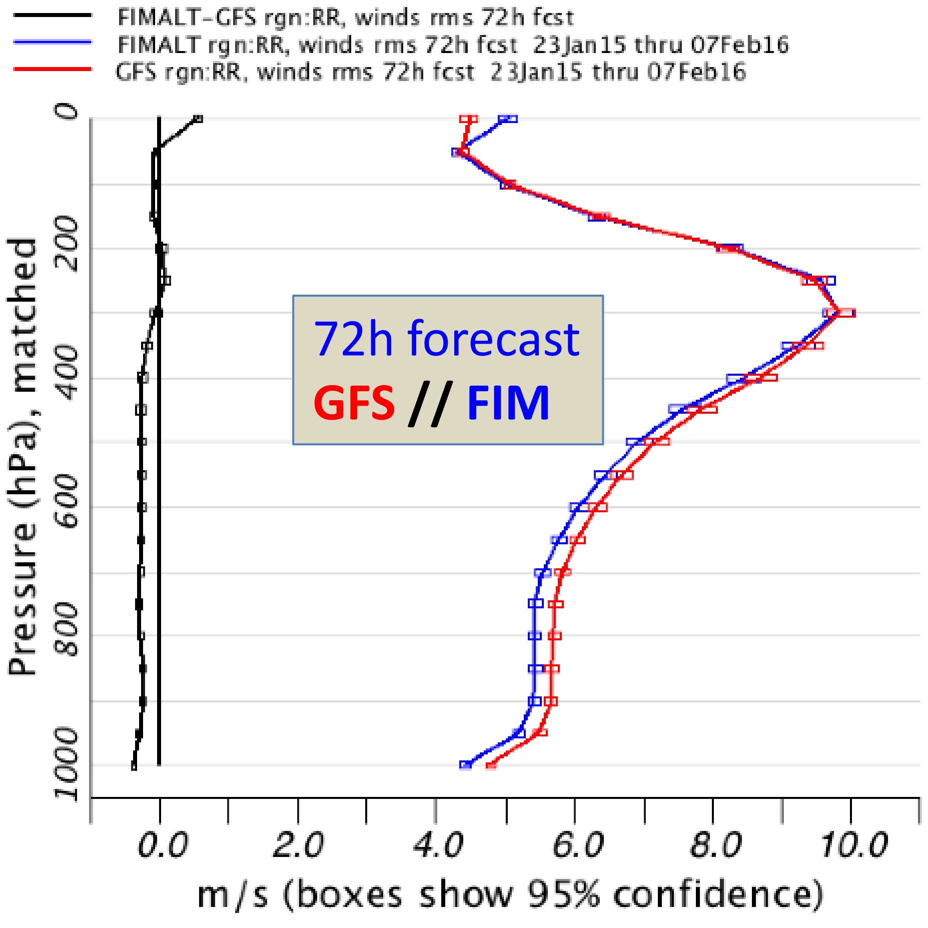
Both using 0.5 lat/lon

RMS errors (smaller better) - verification with rawinsonde observations

–Jan 2015 - Feb 2016



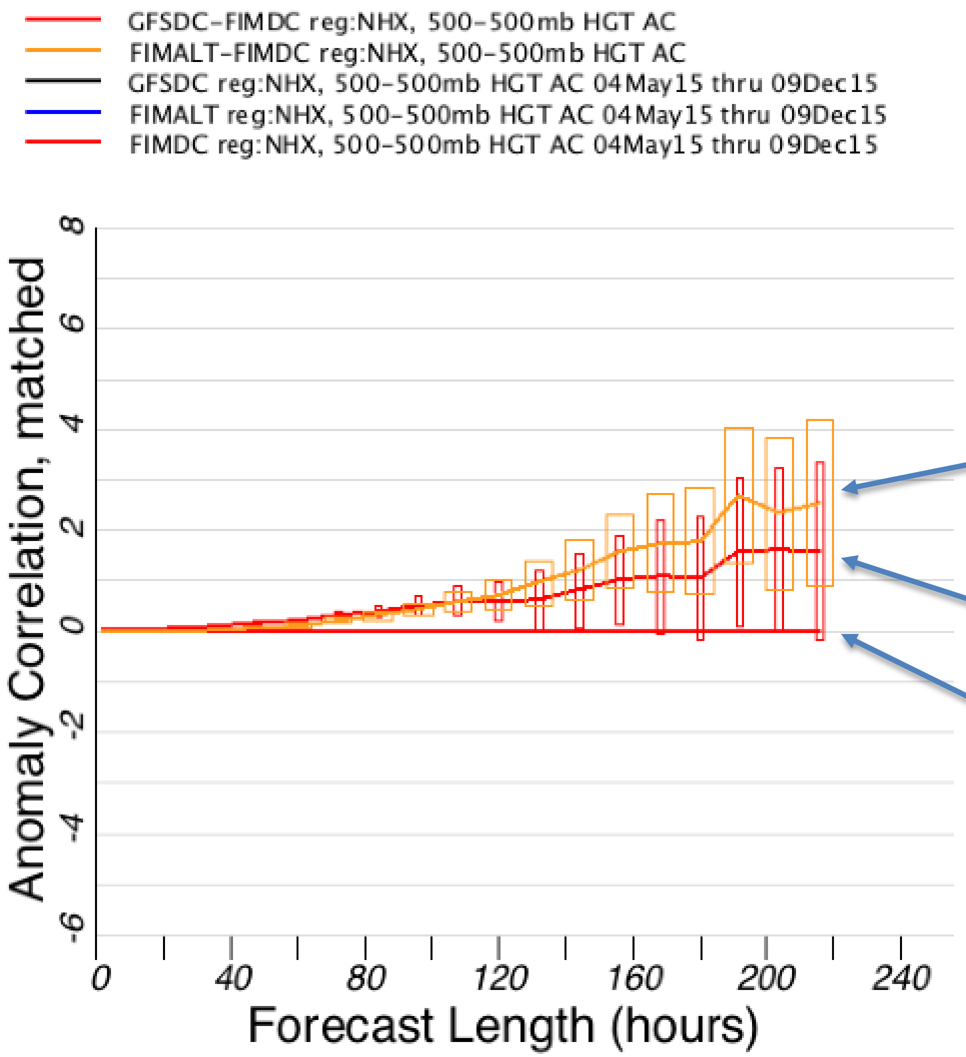
FIM GFS
Better Better



FIM GFS
Better Better

1 – FIM desc
2 – NWP skill
3 – experiments
4 - seasonal coupled exps

500 hPa anomaly correlation
May – December 2015 vs.
FIM30km with recommended T574
gravity wave drag parameters



Result from HIWPP FIM testing:

GSD tests for use of GFS physics
- *Recommend using same gravity wave drag parameters at 30km (or T574) as used at 13-15km (T1534)*

500 hPa anomaly correlation
May – December 2015 vs.
FIM30km with gravity wave drag

FIM30km with T1534 GWD parameters

GFS-T1534 operational

FIM30km with T574 GWD parameters

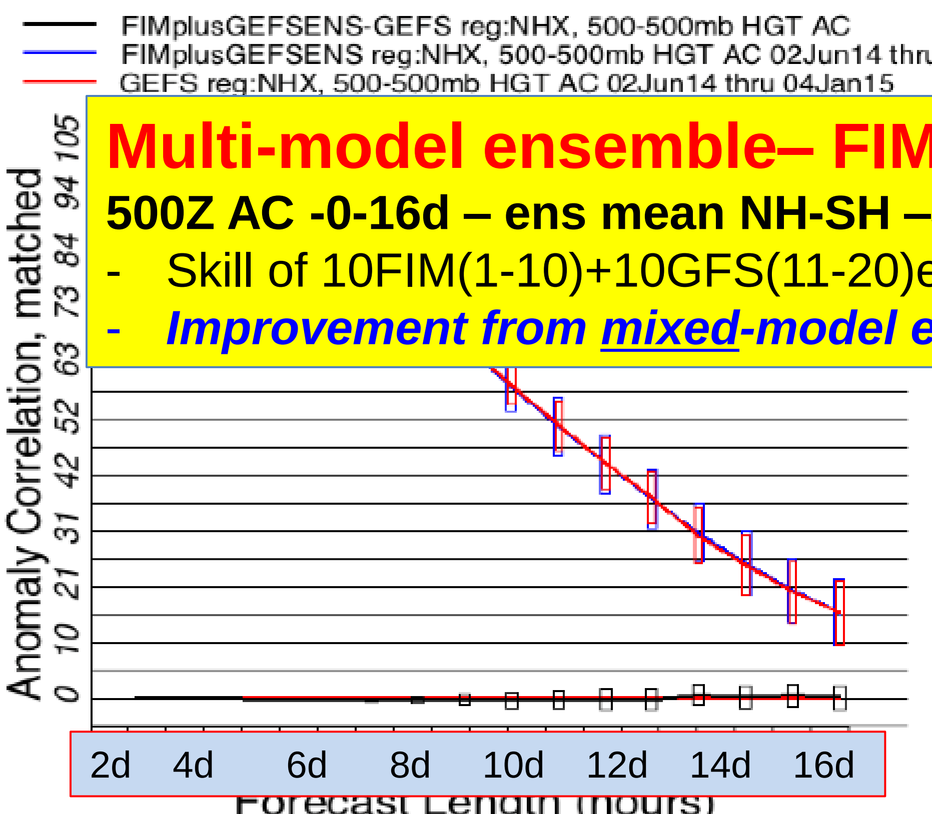
GFS-FIM mixed-model ensemble testing – GSD (Isidora Jankov et al) collaboration with EMC (Yuejian Zhu et al)

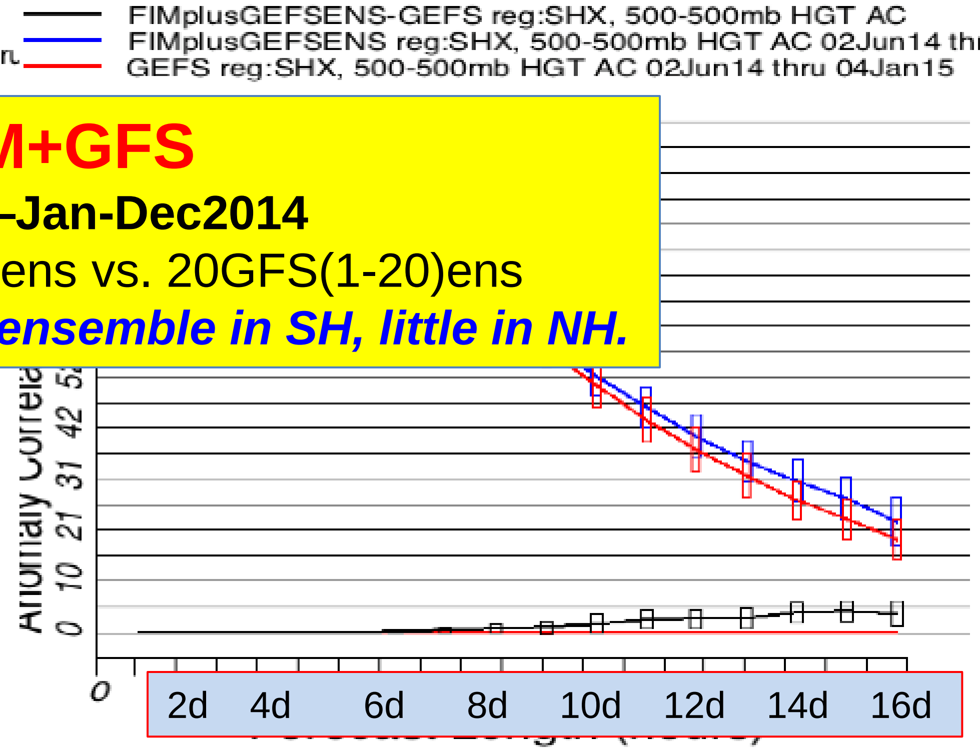
1. Preliminary tests (May-Oct 2015)
2. FIM initial tests – used with problematic GWD parameters (at 40km resolution)
3. New FIM reruns now underway
4. GSD and EMC are planning to complete this study in 2016 to look at
    1. effect of alternative dynamic core
    2. Effect of alternative Grell-Freitas deep convection

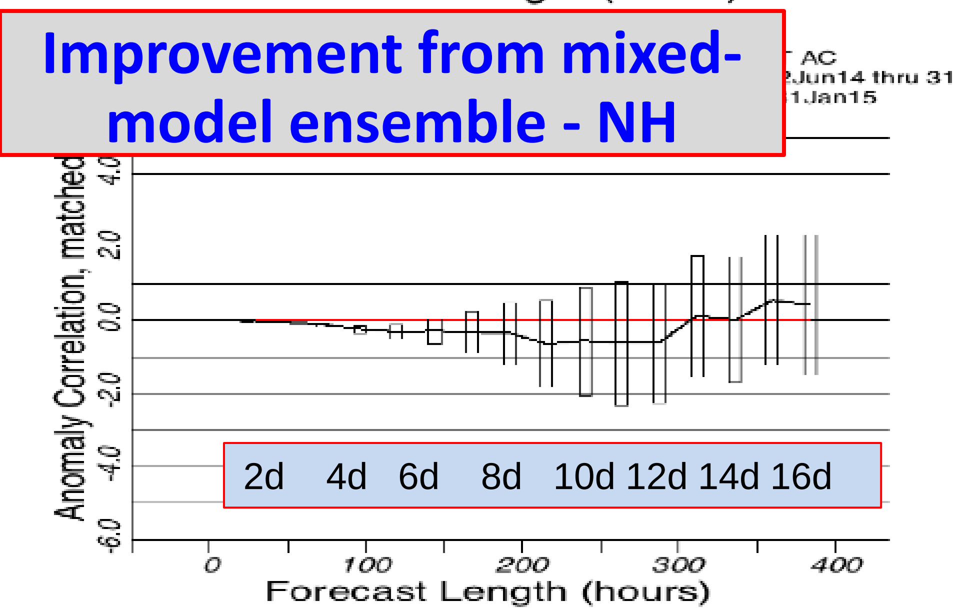
Multi-model ensemble– FIM+GFS

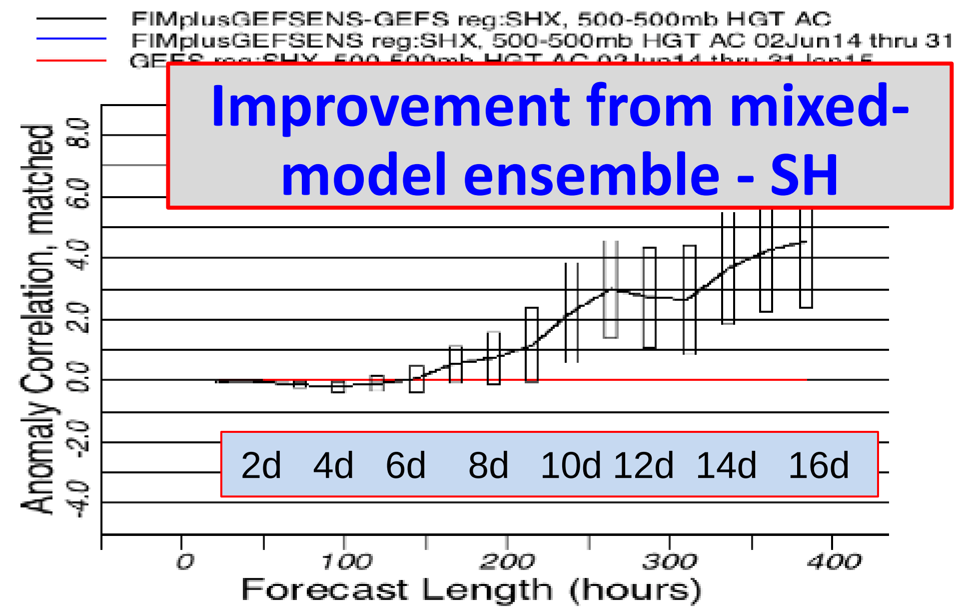
500Z AC -0-16d – ens mean NH-SH –Jan-Dec2014

- Skill of 10FIM(1-10)+10GFS(11-20)ens vs. 20GFS(1-20)ens
- ***Improvement from <u>mixed</u>-model ensemble in SH, little in NH.***









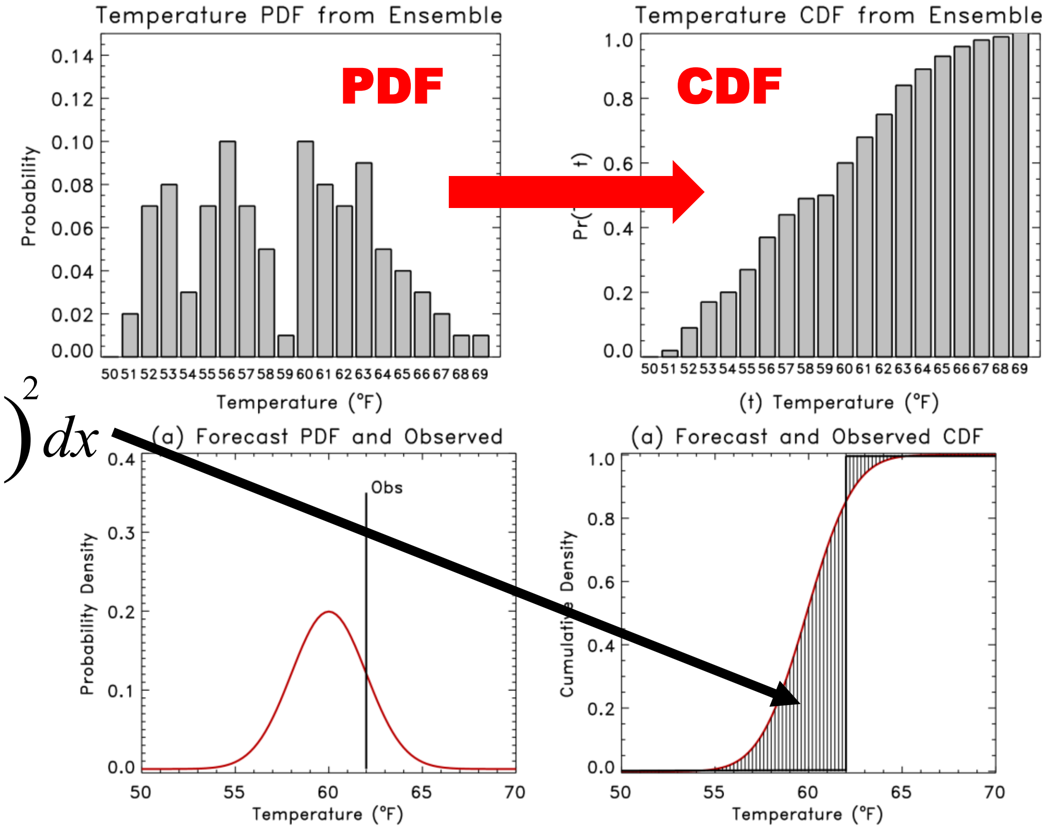
ENSEMBLE verification

- **Evaluation FIM contribution to global ensemble**
- **Evaluation of Continuous Ranked Probability Skill Scores (CRPSS) from GFS + FIM ensemble**
  (Isidora Jankov and Scott Gregory)
- **CRPSS background**

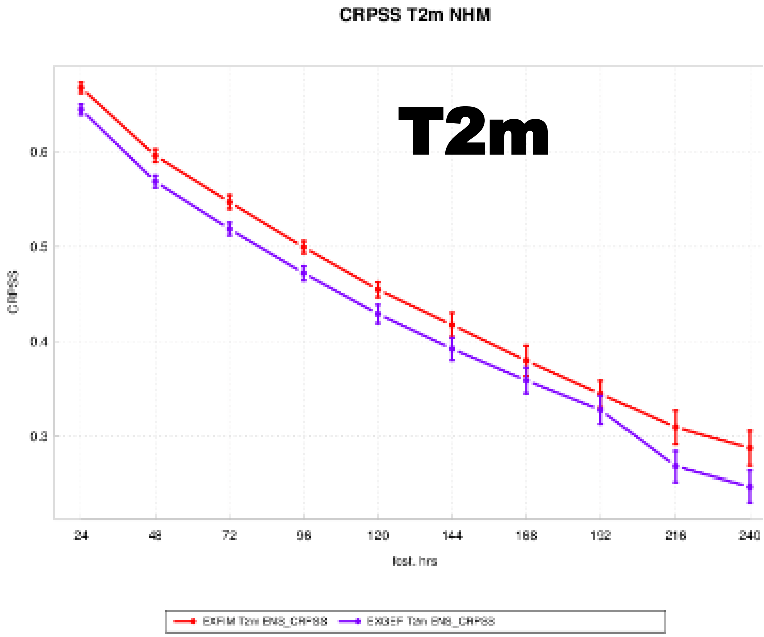
Cumulative distribution function (CDF); used in CRPS

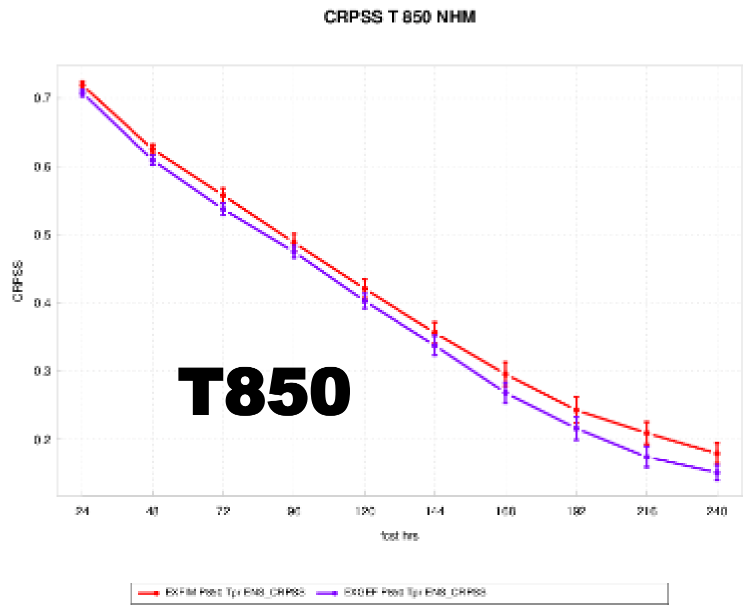
$$CRPS = \frac{1}{n}\sum_{i=1}^{n}\int_{x=-\infty}^{x=-\infty}\left(F_i^f(x) - F_i^o(x)\right)^2 dx$$

$$CRPSS = 1 - \frac{\text{CRPS fcst}}{\text{CRPS ref}}$$



CRPSS summer for T2m, T850 N-hem and S-hem

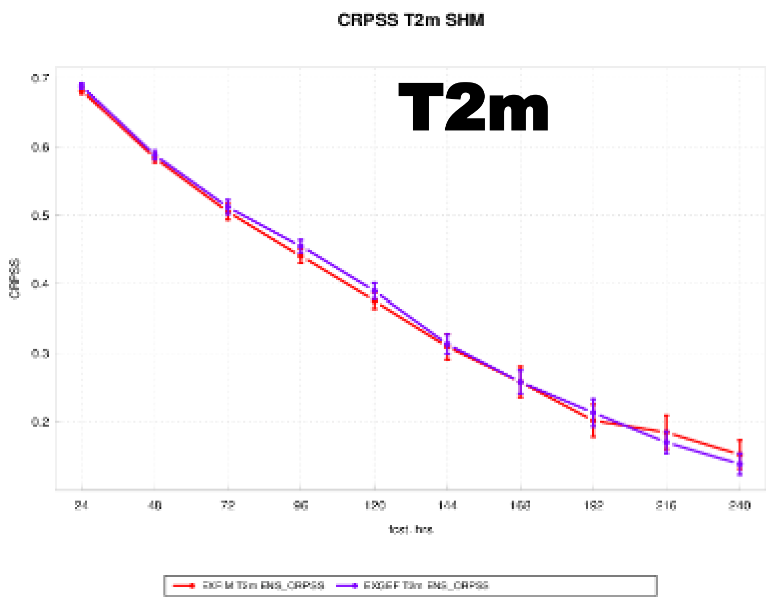


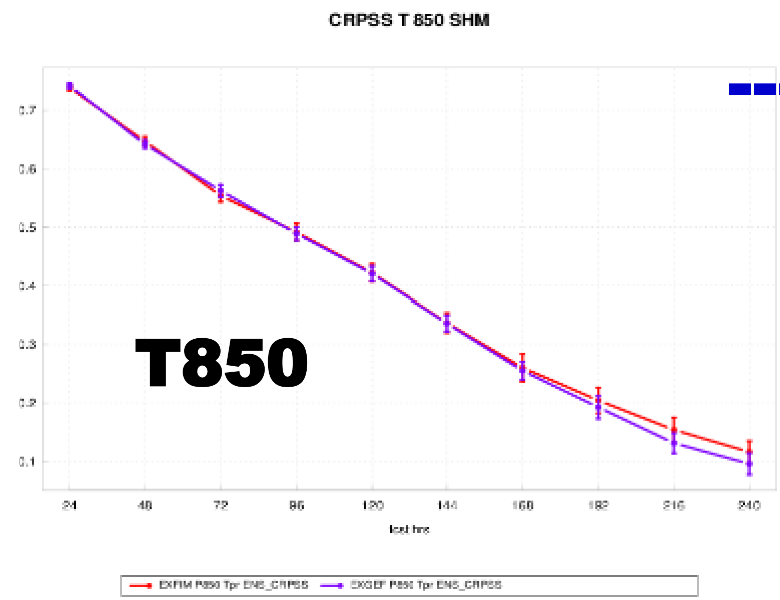


CRPSS Scores North Hemi. summer

---- FIMens +GEFS

--- GEFS



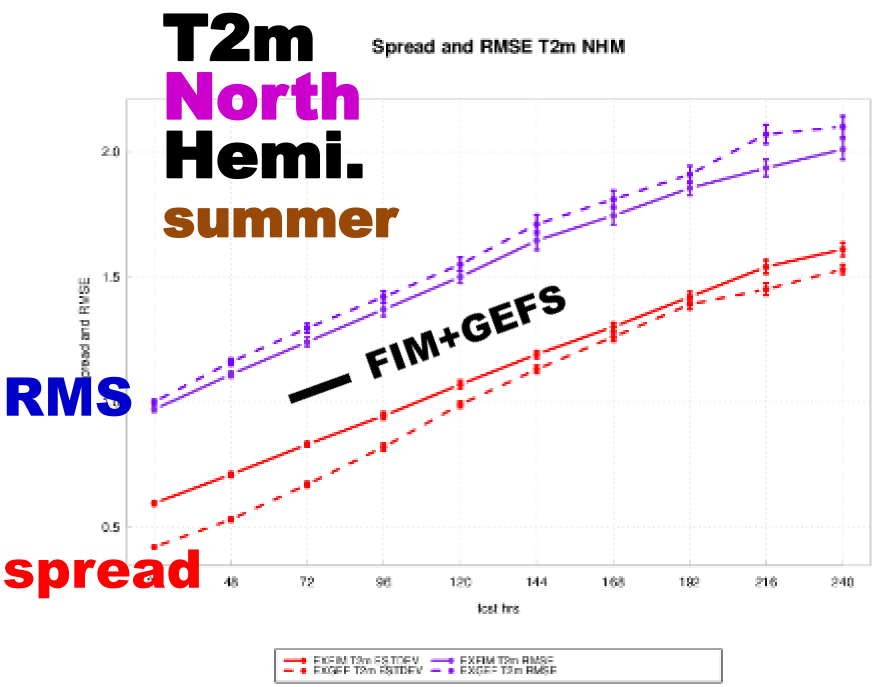


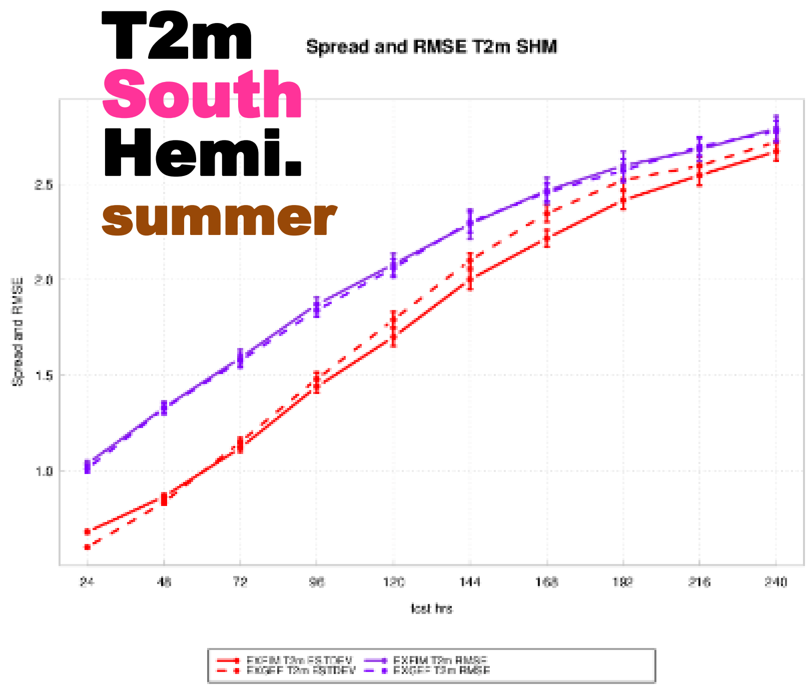
CRPSS Scores South Hemi. summer

Spread and RMSE for T2m for NHM & SHM summer

---- **GEFS spread** ---- **GEFS RMS**

— **FIMens+GEFS spread** — **FIMens+GEFS RMS**





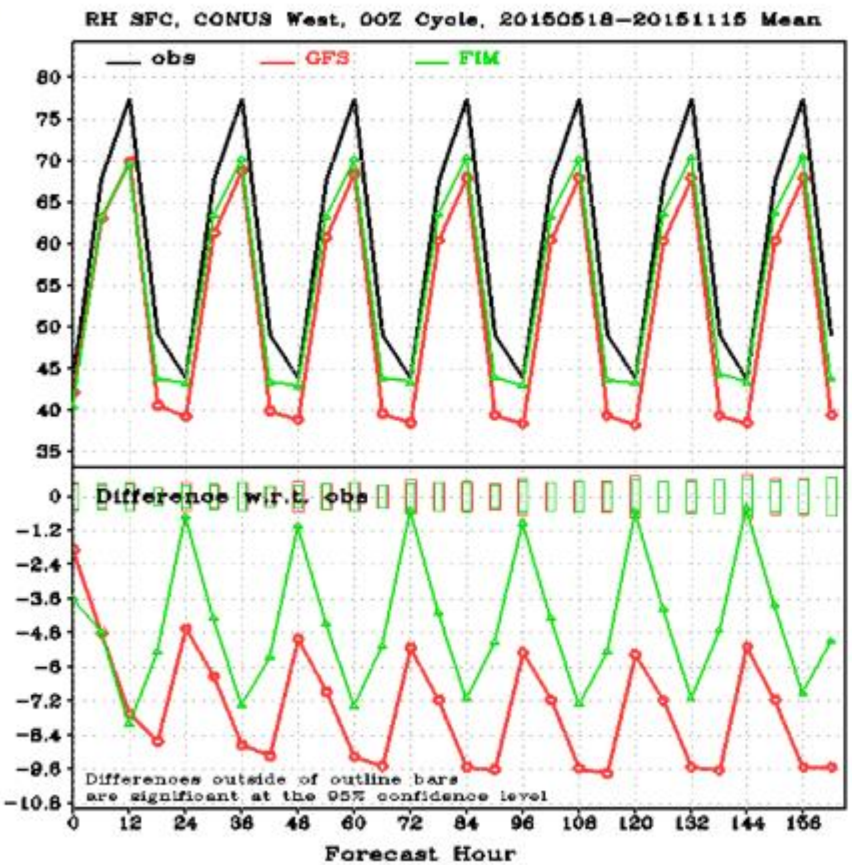
NHM: GEFS characterized with stat. significantly smaller spread than GEFS+FIM for most of the lead times and stat. significantly higher error for earlier lead times.

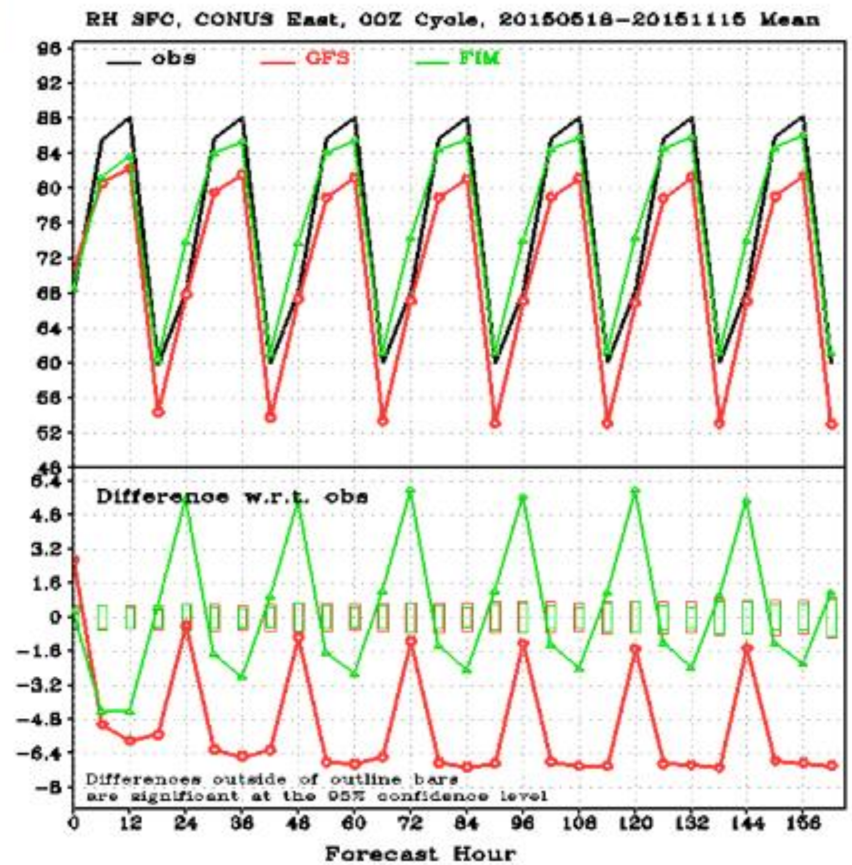
SHM: comparable errors between the two ensembles and better spread for GEFS+FIM at longer lead times

Major problem with warm/dry bias in GEFSp and GFS

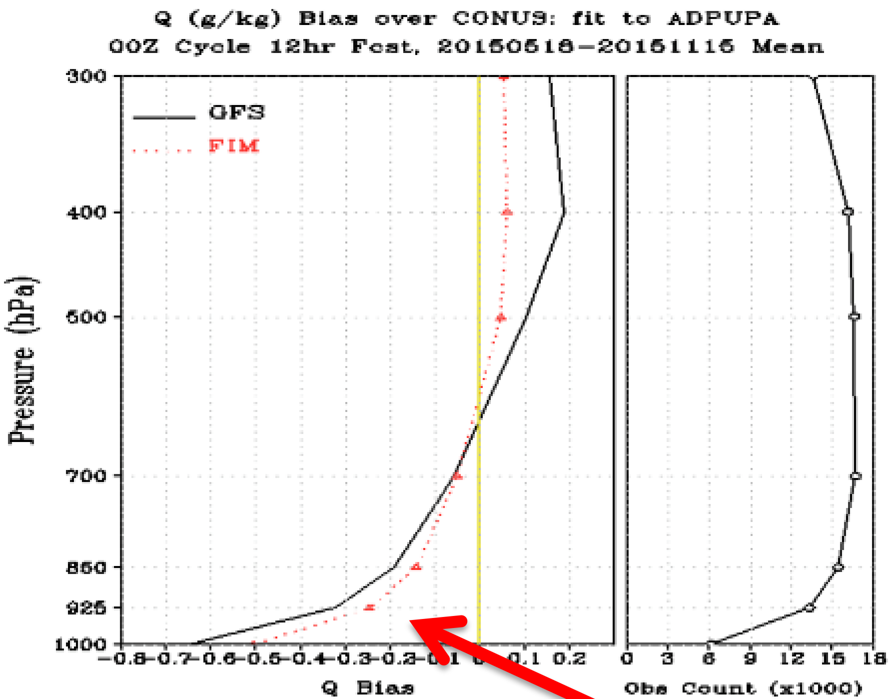
Cited by SPC for recommendation against GEFSp implementation

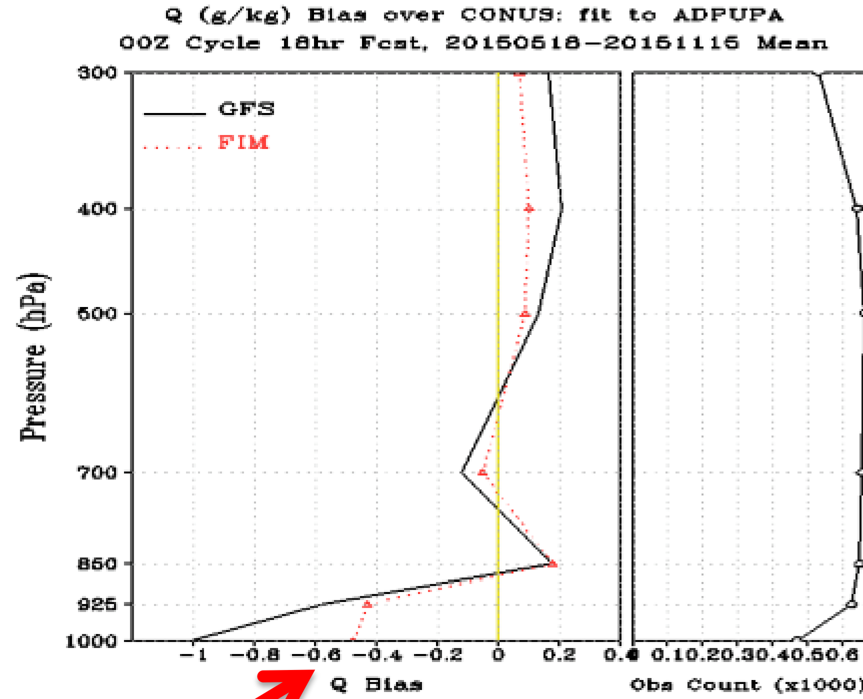
But why does FIM (same 2015-GFS physics, same GFS init conditions including soil moisture/LSM, 30km) not show the same RH bias?





From Fanglin Yang's ongoing GFS-FIM verification
http://www.emc.ncep.noaa.gov/gmb/wx24fy/fim/g2o/index.html





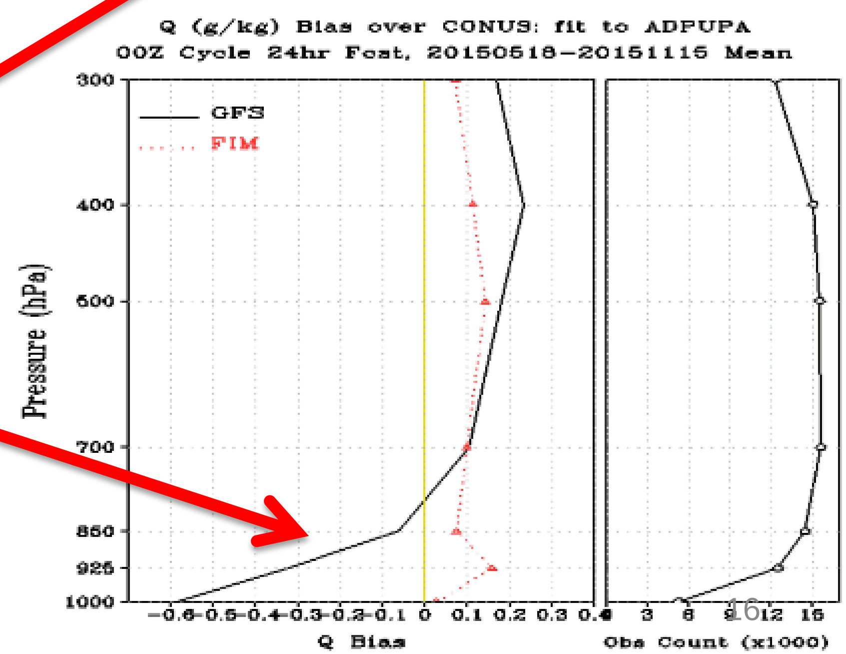
Water vapor mixing ratio (q) bias

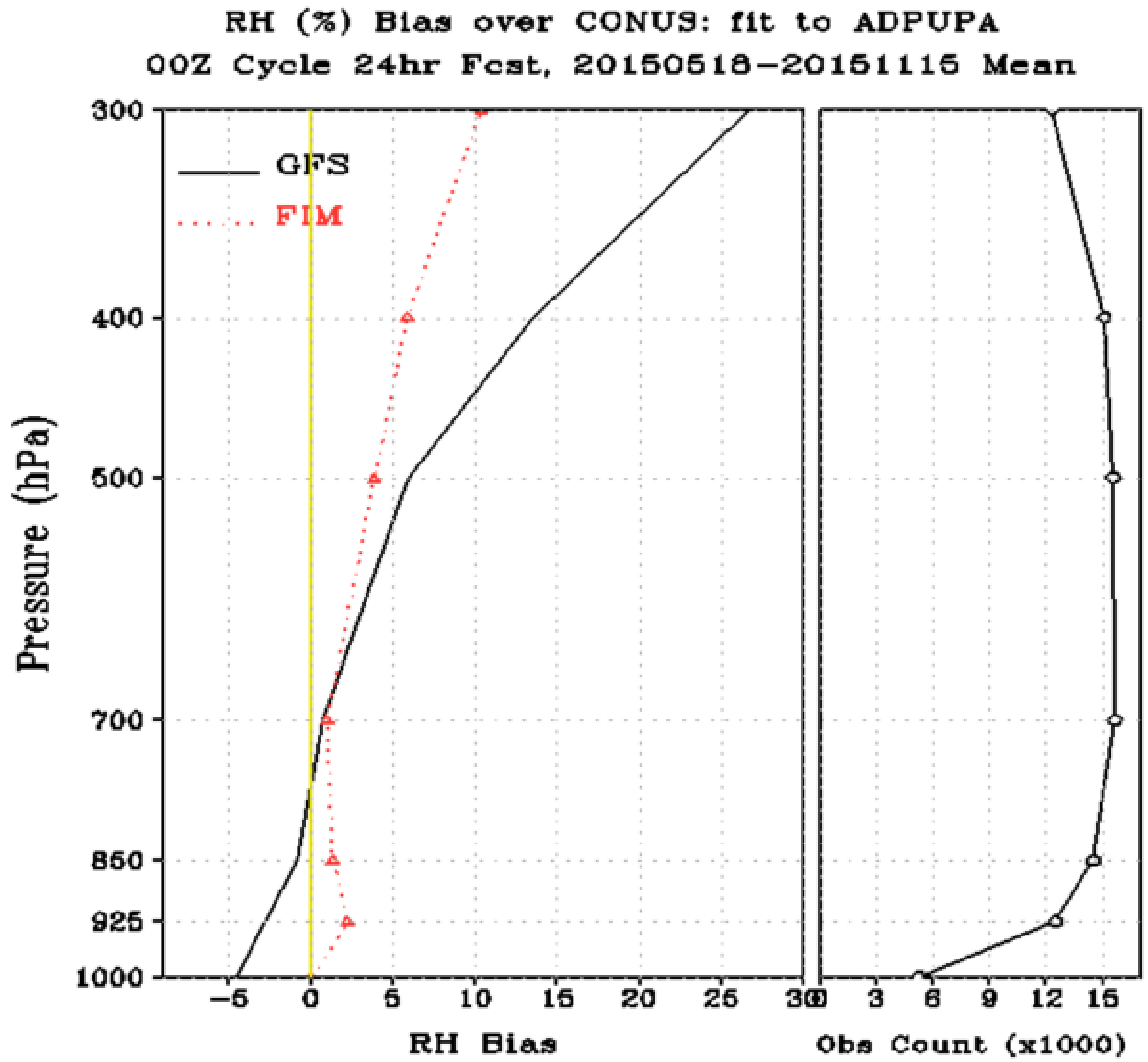
- 12h - FIM and GFS have same 12h dry bias after overnight 12h forecast.
- 18h – now with daytime mixing, FIM is now showing the same dry bias in lowest ~1km.
- 24h – FIM now has a slight moist bias but avoiding the strong GFS dry bias.

2m Td/RH difference is through the PBL

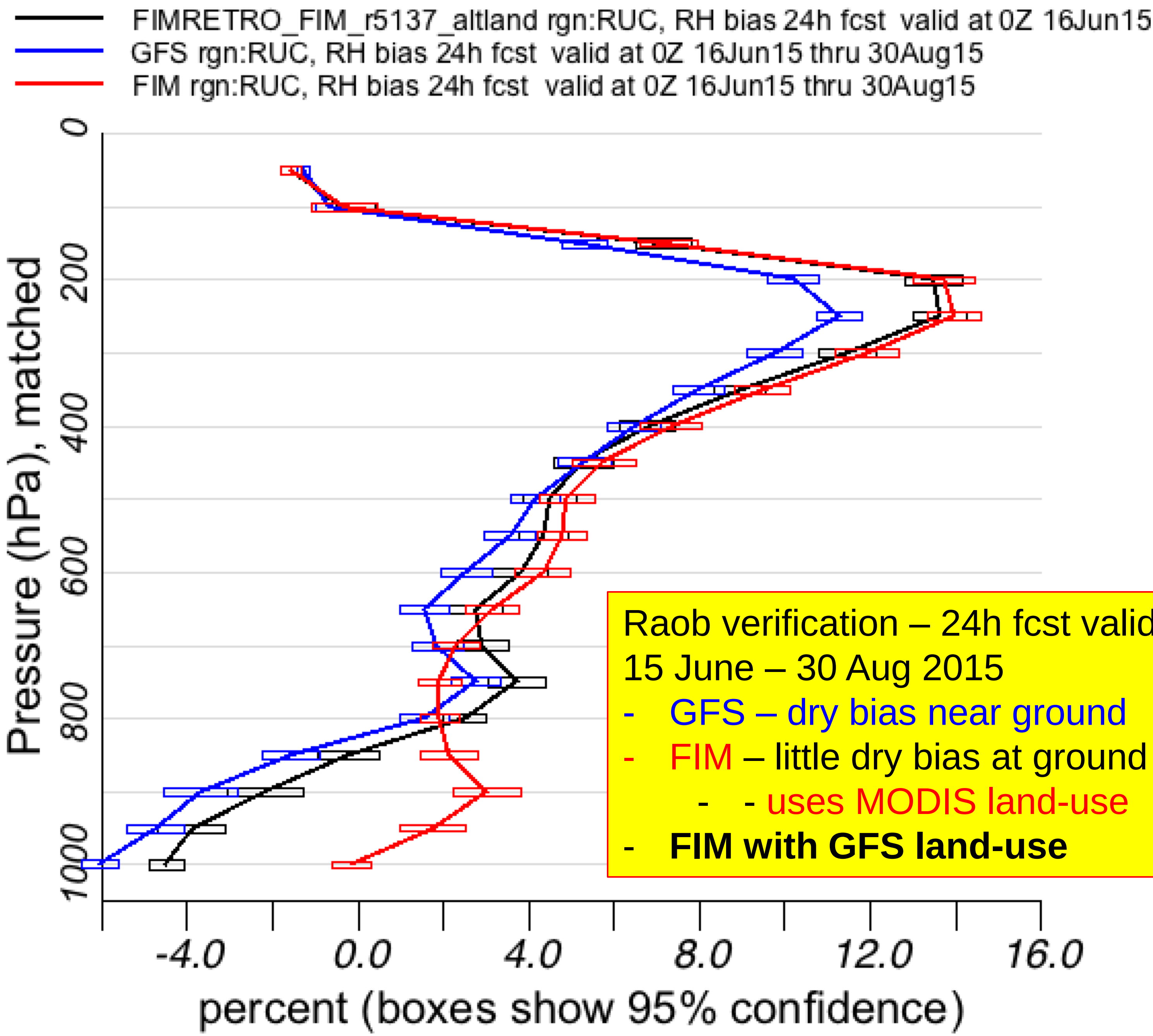
Hypotheses:

- Vertical transport in FIM vs. GFS
- Cloud representation in different vertical stratification.



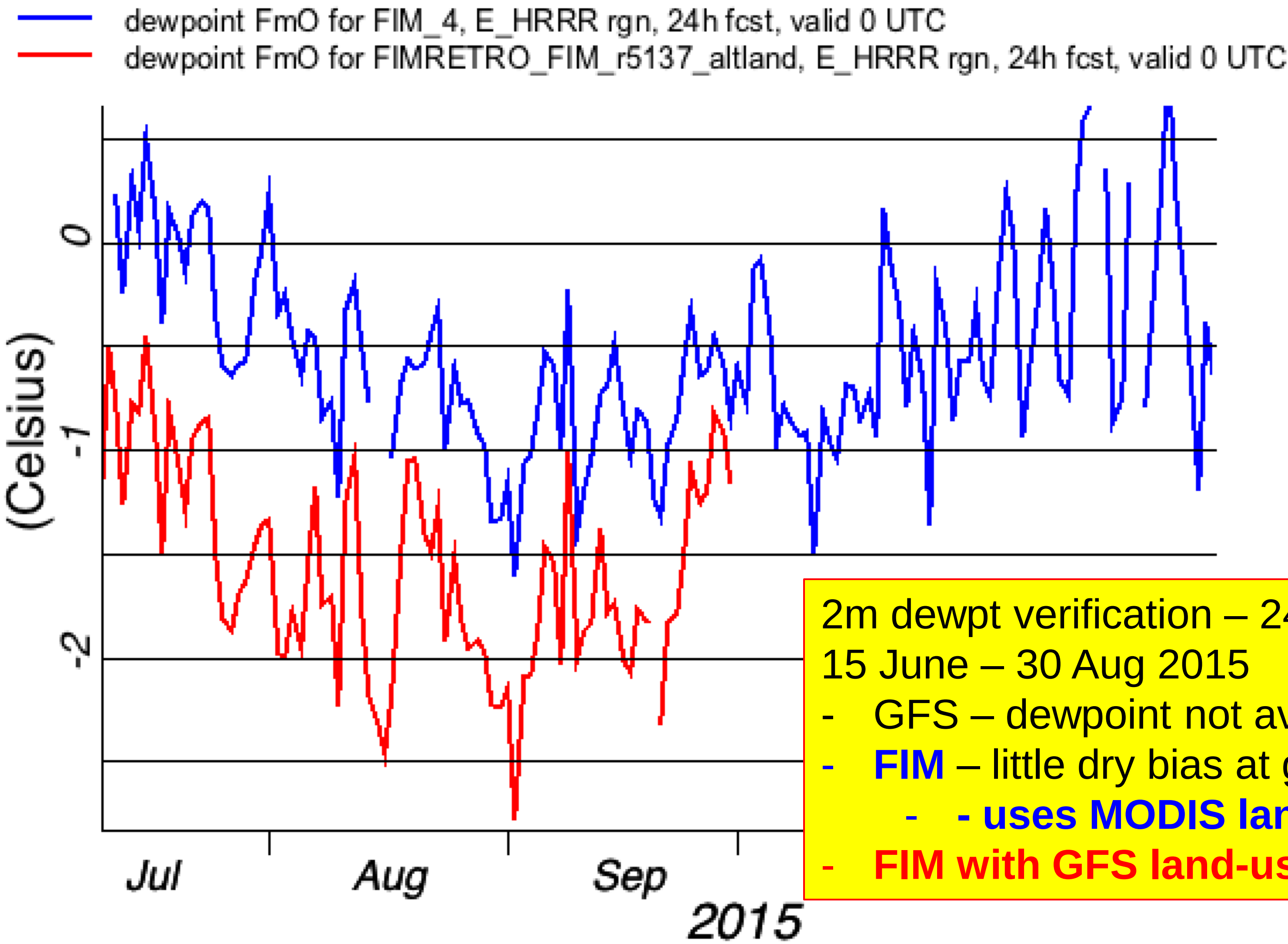


Same RH bias difference between GFS and FIM



Raob verification – 24h fcst valid 00z
15 June – 30 Aug 2015

- GFS – dry bias near ground
- FIM – little dry bias at ground
    - - uses MODIS land-use
- **FIM with GFS land-use**



2m dewpt verification – 24h fcst valid 00z
15 June – 30 Aug 2015

- GFS – dewpoint not available
- **FIM** – little dry bias at ground
    - **- uses MODIS land-use**
- **FIM with GFS land-use**

Key aspects of HIWPP advanced hydrostatic model testing

- Participants
  - NCEP – GFS
  - ESRL – FIM – alternative dycore, GFS physics, GFS IC
  - NRL – NAVGEMx – GFS IC
- Results
  - Controlled experiments with common GFS IC and GFS physics
  - FIM
    - improved wind RH forecasts improved over NCEP GFS
    - Improved 500z AC for N.Hemis for 6-10 day fcsts
    - Recommendations on gravity wave drag and MODIS land-use option
    - FIM+GFS mixed-model (10+10) ensemble testing – EMC/ESRL collaboration, continued testing and evaluation
- Related NGGPS plans
  - Similar retrospective experiments to attempt to match or exceed HIWPP advanced hydrostatic global model results
  - Extensive development of dycore(s), physical parameterizations, data assimilation