3.6 NCEP's Global Icing Ensemble Prediction and Evaluation

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Outline

➢ Motivation

➢ History of icing prediction at NCEP

➢ Configuration of icing prediction from Global Ensemble Forecast System (GEFS)

➢ Verification of GEFS icing prediction

➢ Future Work

➢ Summary

Motivation

❑ "En-route" icing is one of several hazardous conditions for flights

~ NCEP dedicated a lot of effort to produce icing forecast with support from the FAA and ICAO (WAFS)

❑ Global ensemble forecasts of icing potential is new at NCEP

~ Performance evaluation and baseline for future

- ❑ An icing product was first initiated in the regional ensemble (SREF, 2003)
  - Simple algorithm (yes/no) was based on T, RH, and updraft speed

- ❑ Global icing forecast began in 2006 (requested by for WAFS/ICAO)
  - Diagnosed using the NCAR fuzzy logic algorithm

- ❑ Fuzzy logic was added to NCEP's Unified Post Processor (UPP) in 2011
  - GFIP and Global Current Icing Potential (GCIP) in 2015, Global Forecast of Icing Severity (GFIS) in 2016
  - Max, NCEP/UKMet blended icing potential products, etc
  (ref: H. Chuang's talk (11.1) on 1/26 Thursday)
- ❑ GEFS Icing Potential was implemented in Dec. 2015
  - First global ensemble icing product at NCEP

GEFS Icing Potential

❑ **Configuration of GEFS icing potential**

- 20 members +1 control (goes with GEFS members)

- 4 runs/day (00, 06, 12 and 18Z), every 6 hr output to 48 forecast hrs

- 6 Flight Levels: FL300 (30000 feet), FL240, FL180, FL140, FL100, FL060

- 2 Global resolution domains

  * 0.5 deg x 0.5 deg and 1 deg x 1 deg

- 3 Ensemble products can be generated (mean, spread and probability)

  * Not produced operationally

  * Users need to process locally

  * Experimentally generated and displayed at

http://www.emc.ncep.noaa.gov/mmb/SREF_avia/FCST/GEFS/web_site/html/icing.html

GEFS Icing Potential

Ensemble Mean 24-h valid at 06Z 11/1/2016

GEFS: Ensemble Mean of Icing Potential at FL060. 24H FCST from 06z Oct 31 2016. Verified Time: 06z 11/1/2016
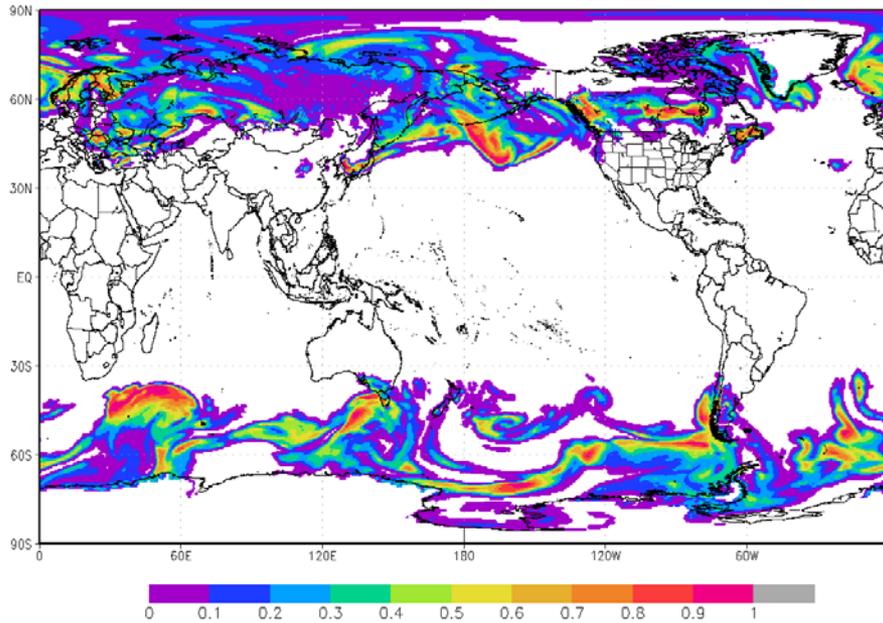
FL060

GEFS: Ensemble Mean of Icing Potential at FL180. 24H FCST from 06z Oct 31 2016. Verified Time: 06z 11/1/2016
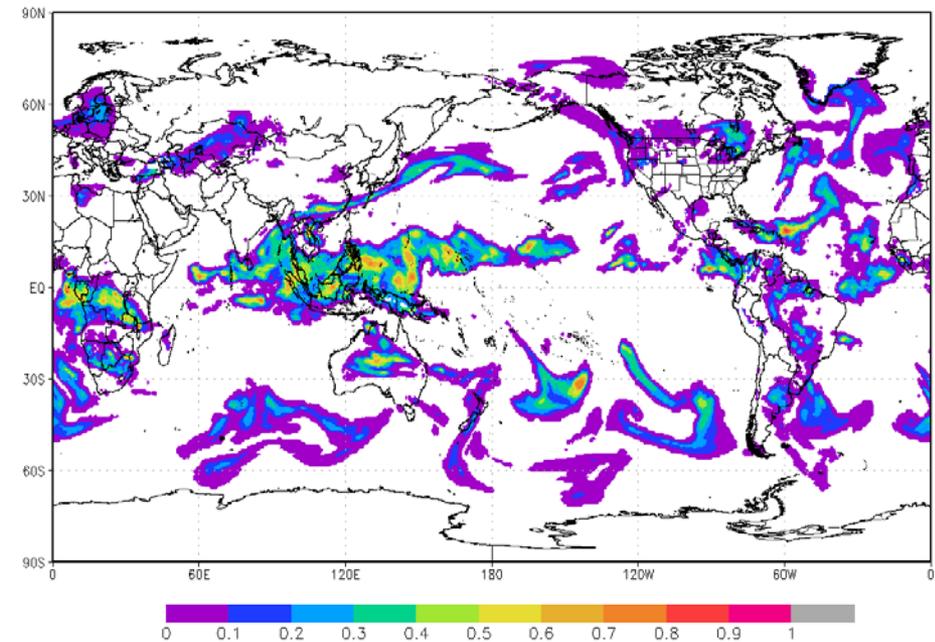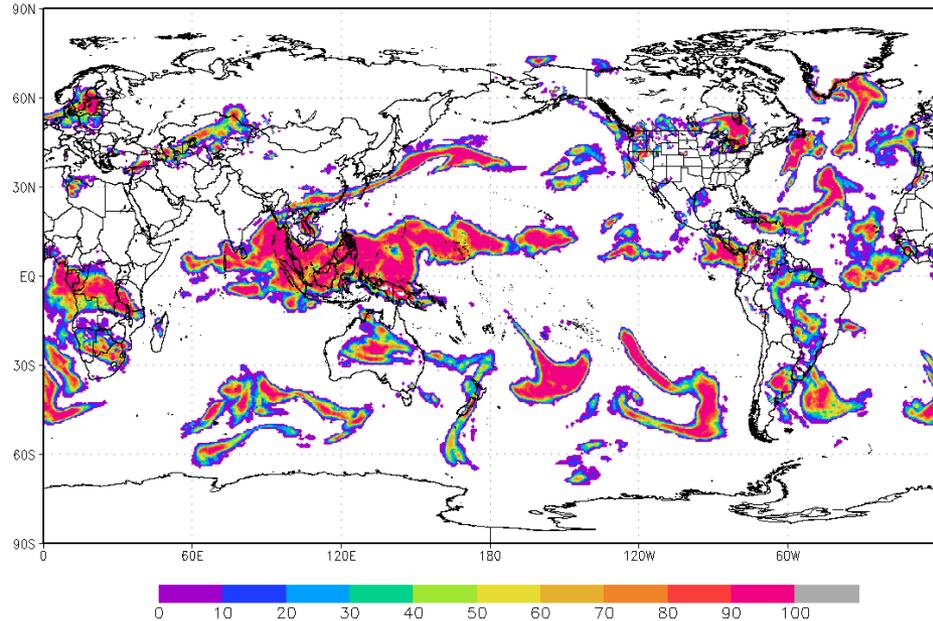
FL180

GEFS Icing Potential

24-h probabilites valid at 06Z 11/1/2016

GEFS: Probability of Icing Potential > 0.1 at FL180. 24H FCST
from 06z Oct 31 2016. Verified Time: 06z 11/1/2016

GEFS: Probability of Icing Potential > 0.7 at FL180. 24H FCST
from 06z Oct 31 2016. Verified Time: 06z 11/1/2016

GrADS: COLA/IGES

2016-10-31-12:04

GrADS: COLA/IGES

2016-10-31-12:04

24 hr Prob fsct for IP>0.1 at FL180

24hr Prob fcst for IP>0.7 at FL180

Verification of GEFS Icing Potential

❑ **Verification period**
   - June ~ Oct 2016
❑ **Validation data**
   - GCIP Analysis as truth (GCIP has been verified against CIP over CONUS)
❑ **Ensemble verification metrics**
   1. Ensemble system overall evaluation
      - Spread Skill Score (Spread/RMSE)
      - Mean error (mean bias)
      - Continuous Ranked Probabilistic Score (CRPS, indicate error)
      - Continuous Ranked Probabilistic Skill Score (CRPSS, GFIP as reference)
      - Reliability diagram
      - ROC area
   2. Event-driven performance (thresholds >0.1, 0.3, 0.5, 0.7, and 0.9)
      -Probability ~ Event
       * Transfer probabilistic forecast to deterministic forecast by using certain
         probability threshold (e.g. ensemble probability > 50%)

24-h GEFS Icing Potential RMSE
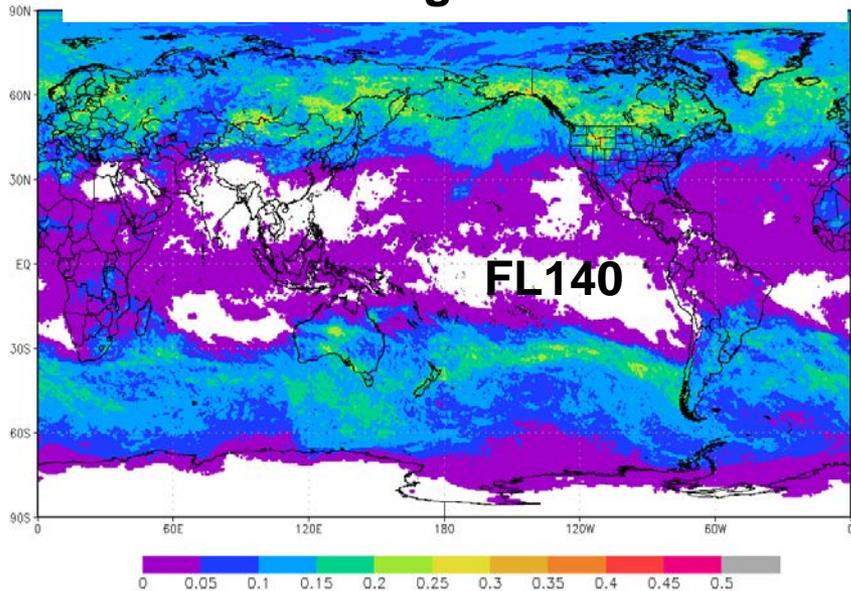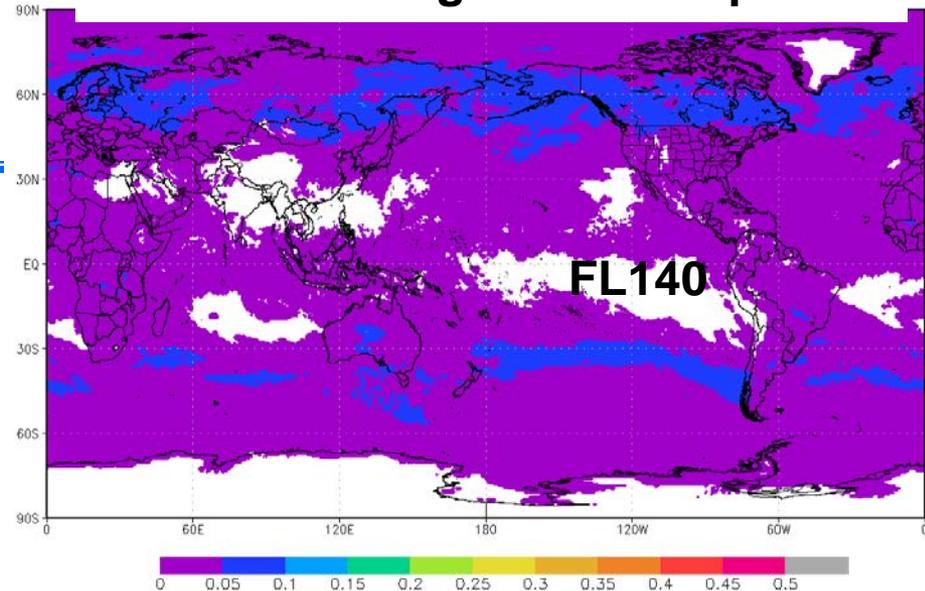
24-h GEFS Icing Potential Spread

FL140

FL140

24-h GEFS Icing Potential RMSE

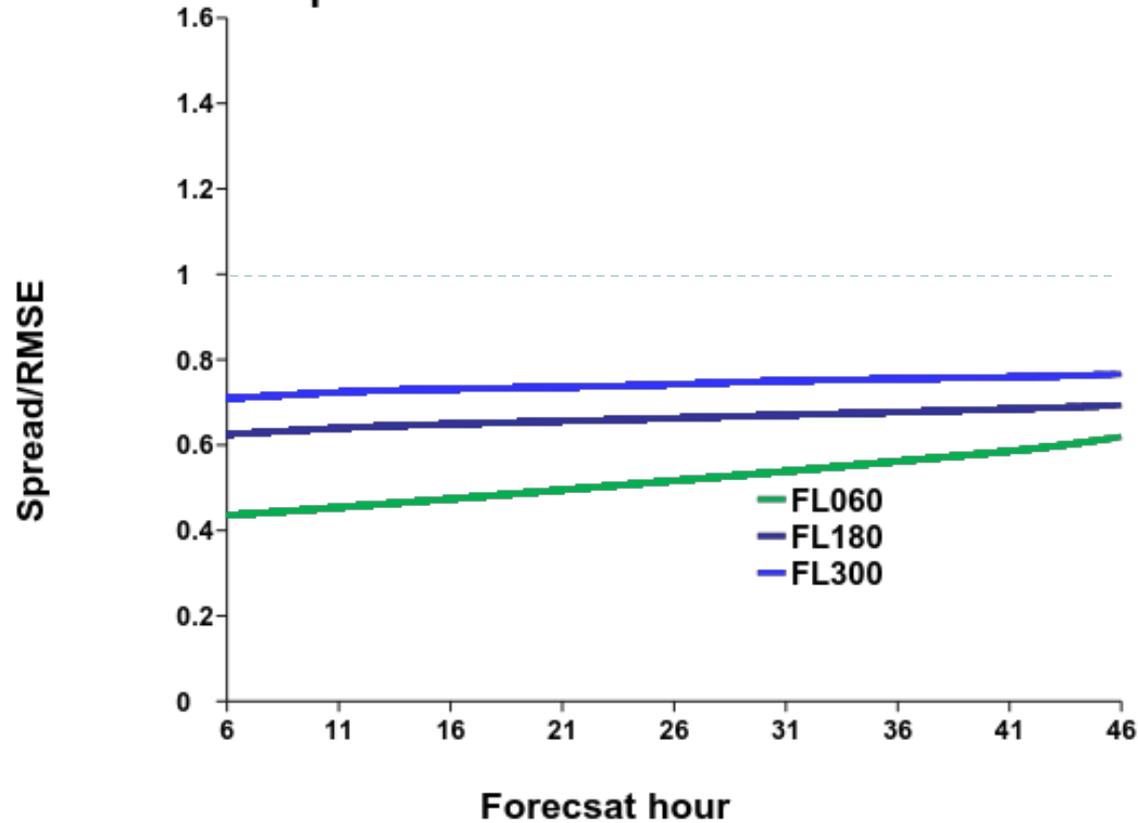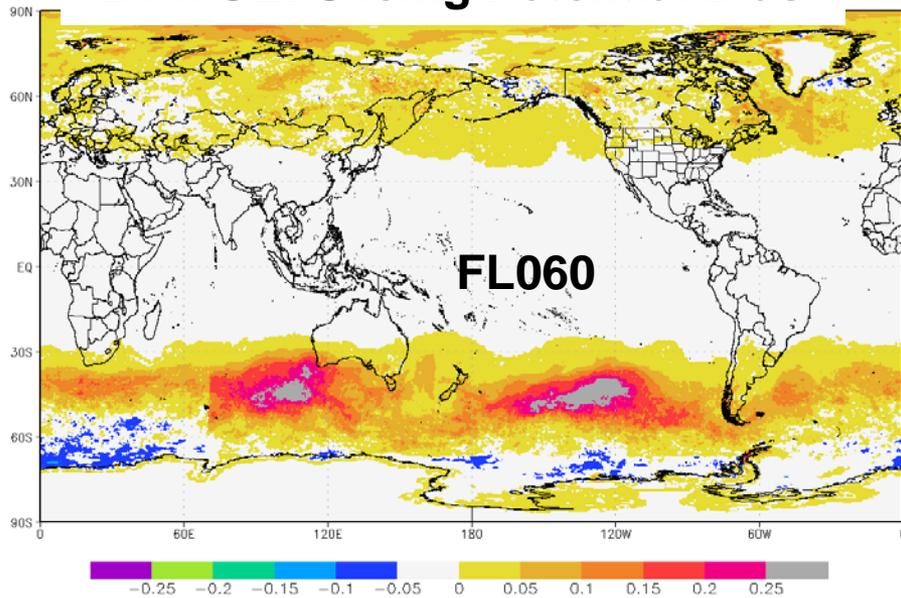**24-h GEFS Icing Potential Spread**

FL300

FL300
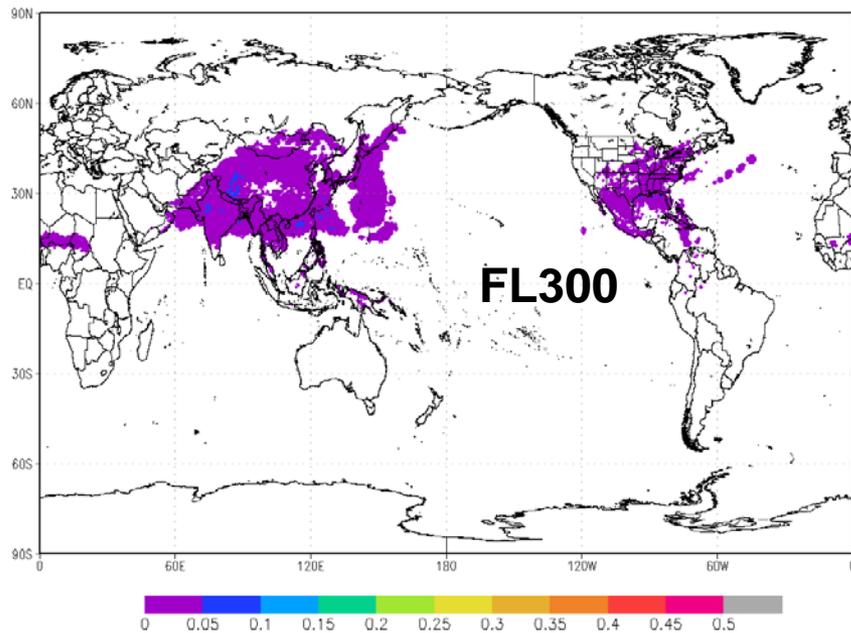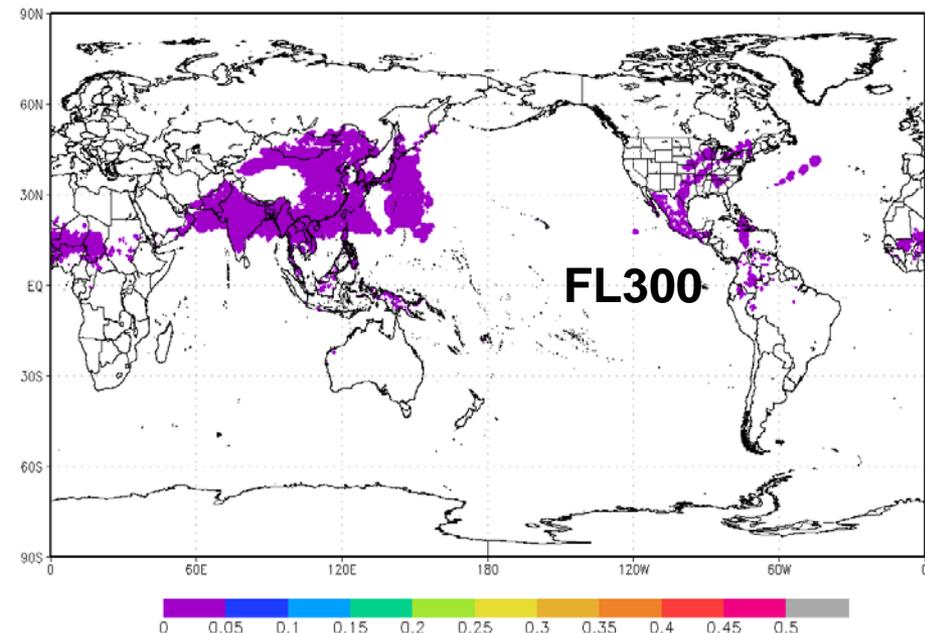
Performance

Spread Skill over Entire Global Domain
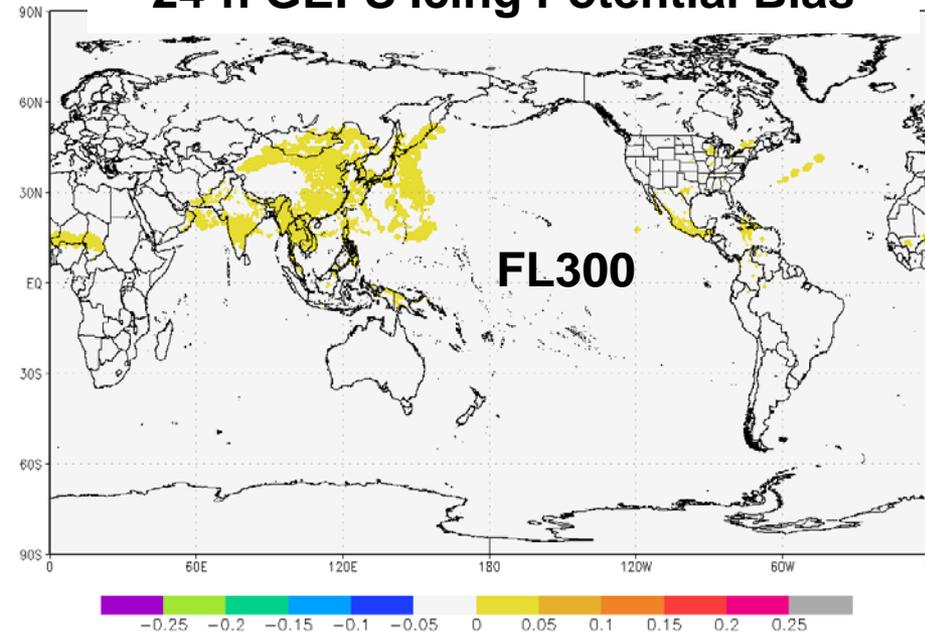
24-h GEFS Icing Potential Bias
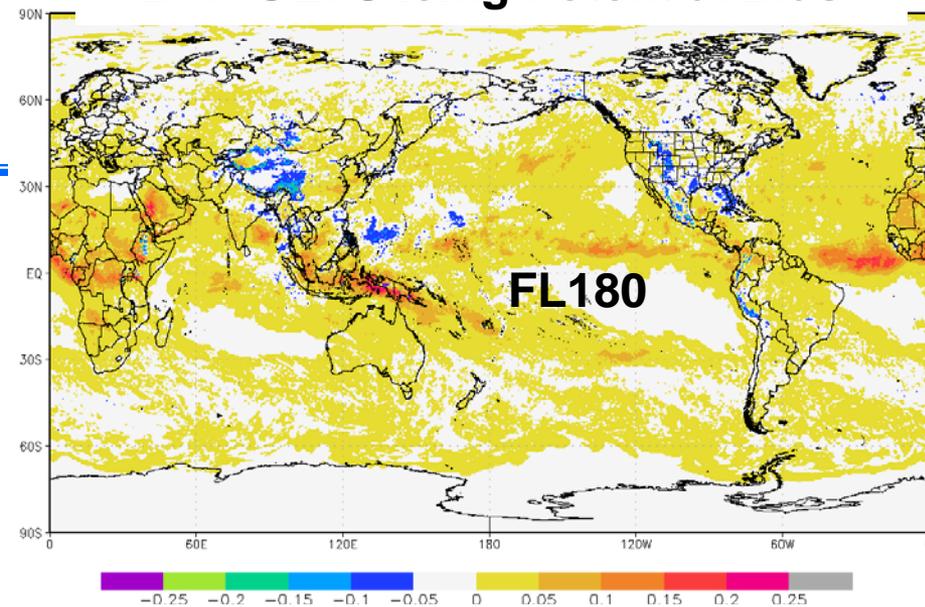
FL060

24-h GEFS Icing Potential Bias

FL180

24-h GEFS Icing Potential Bias

FL240

24-h GEFS Icing Potential Bias

FL300
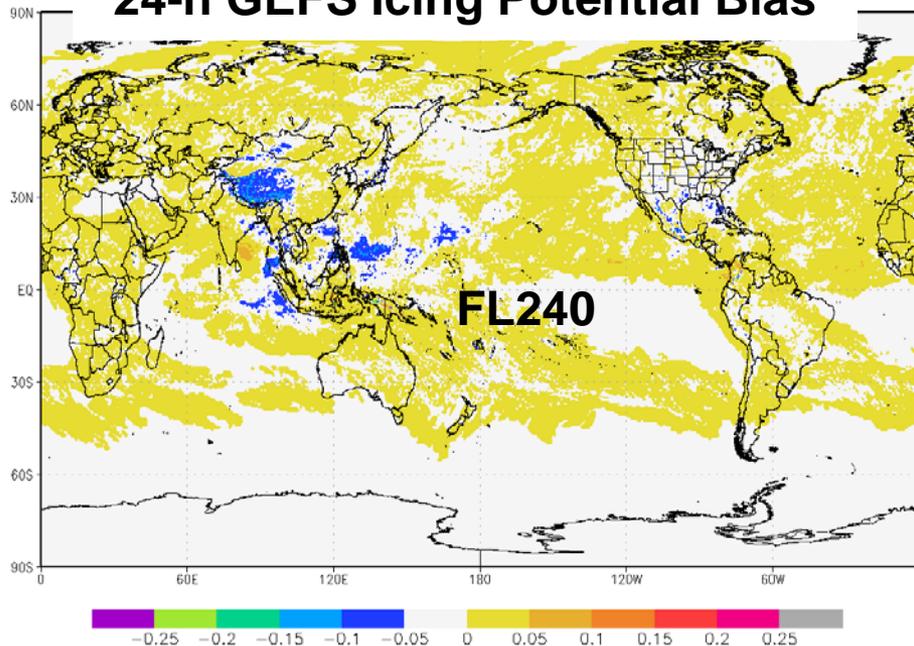
CRPS at different Flight Levels over Entire Global Domain
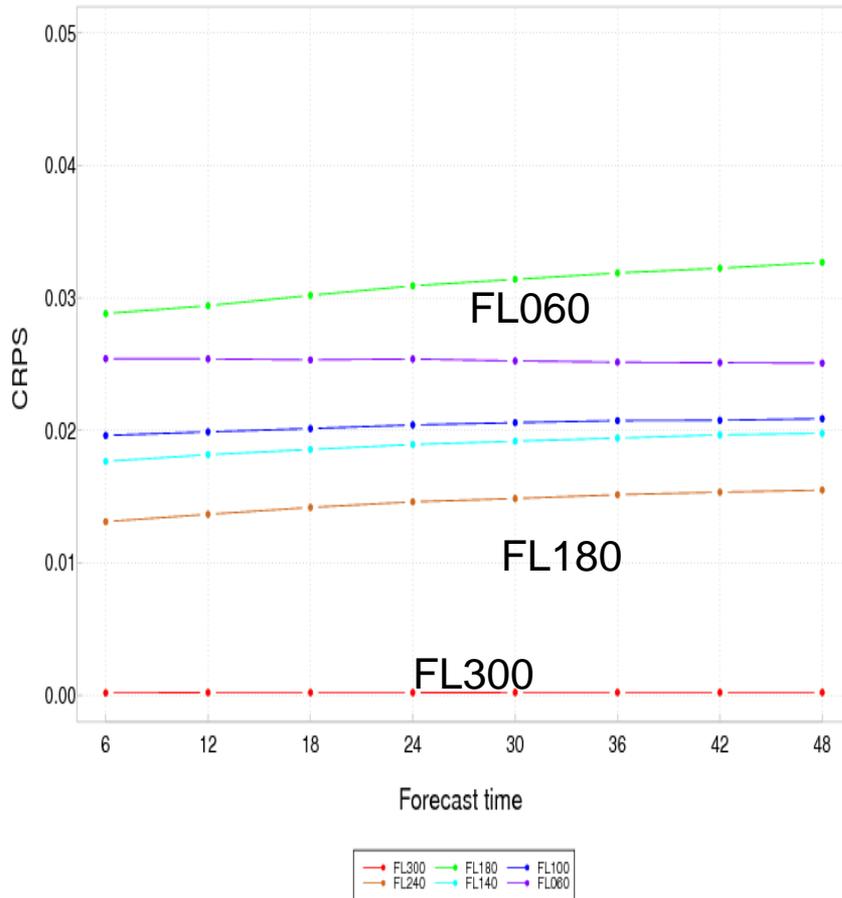
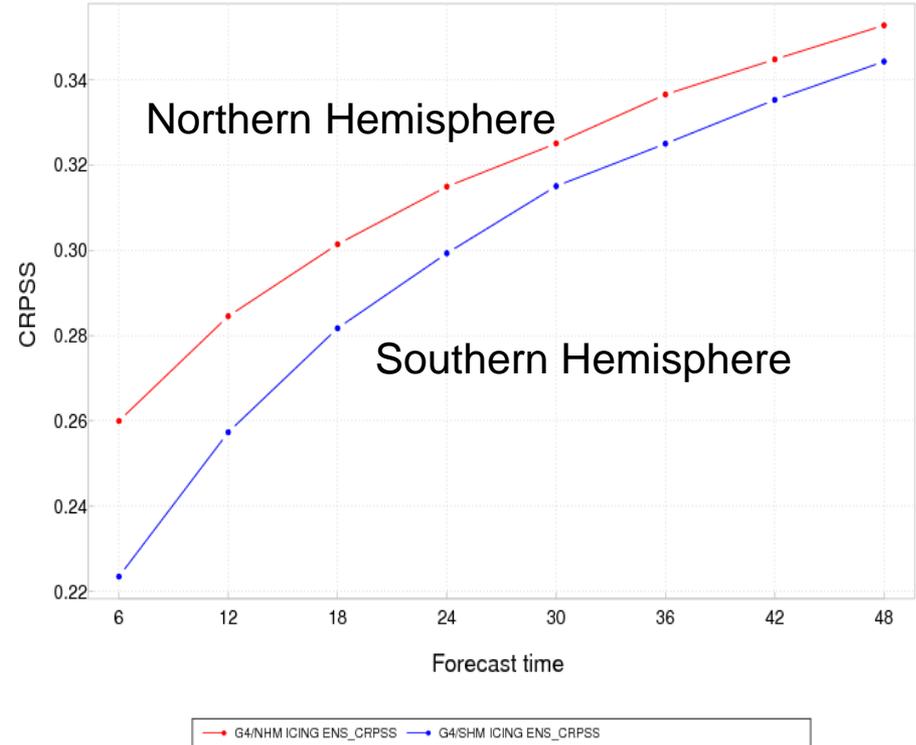CRPSS (refer to GFS) over Entire Global Domain at Different Flight Levels
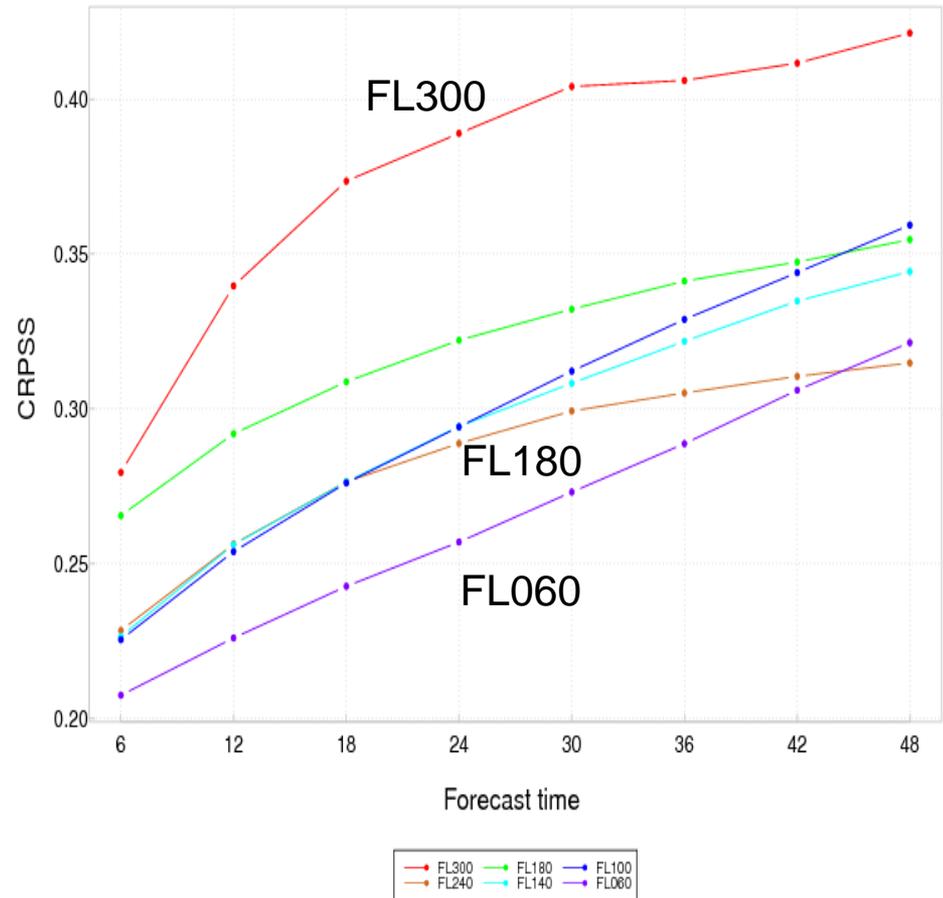
CRPS over N. Hemisphere and S. Hemisohere between FL140~FL180

Northern Hemisphere

Southern Hemisphere

CRPSS (refer to GFS) over S. Hemisphere and N. Hemisphere between FL140~FL180
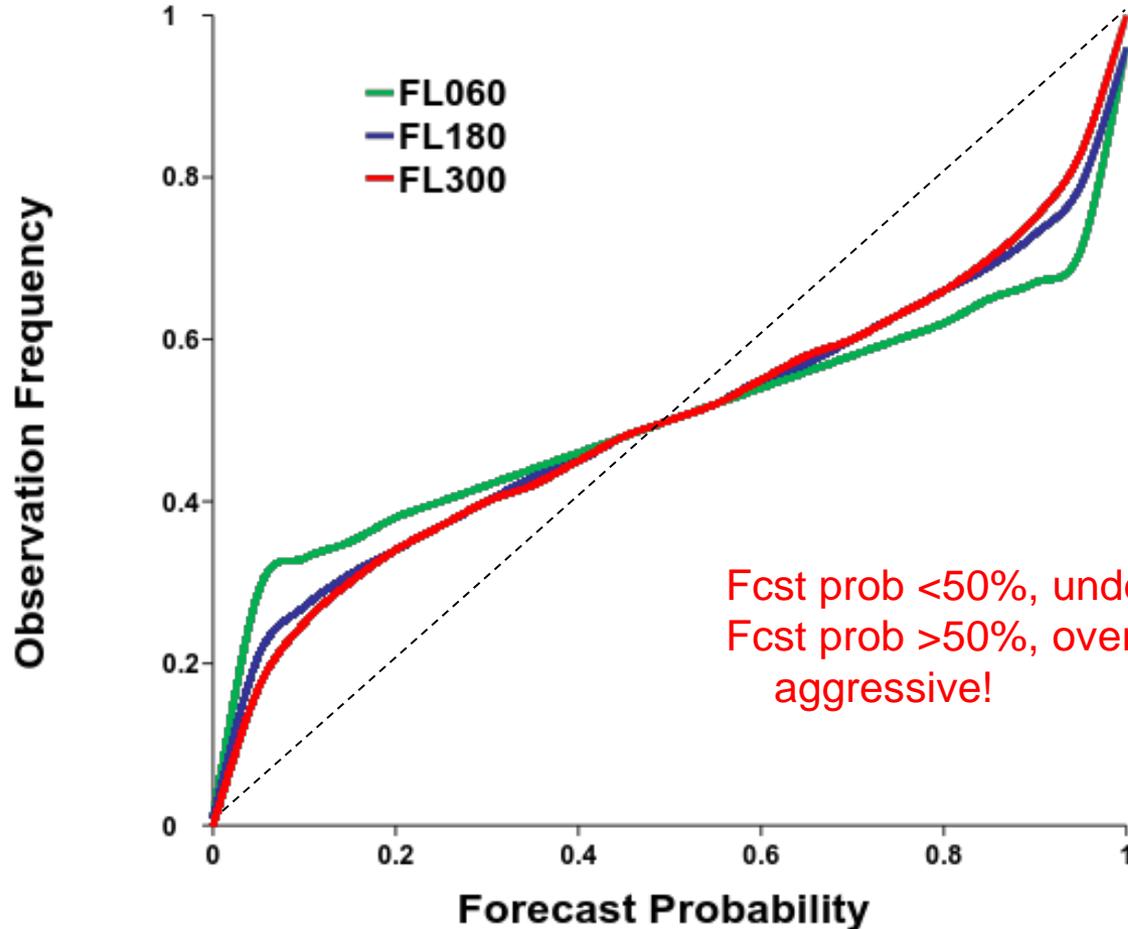
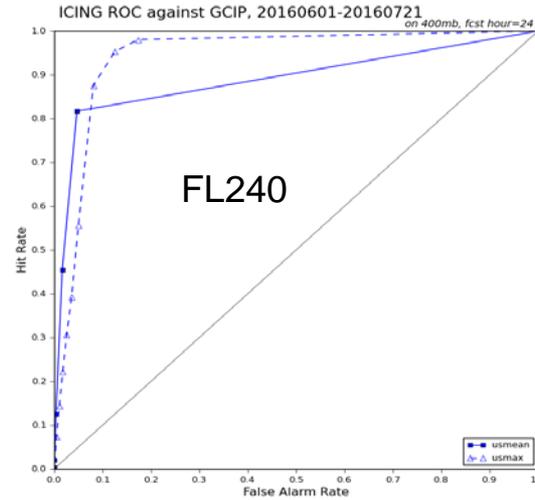Northern Hemisphere

Southern Hemisphere

Reliability

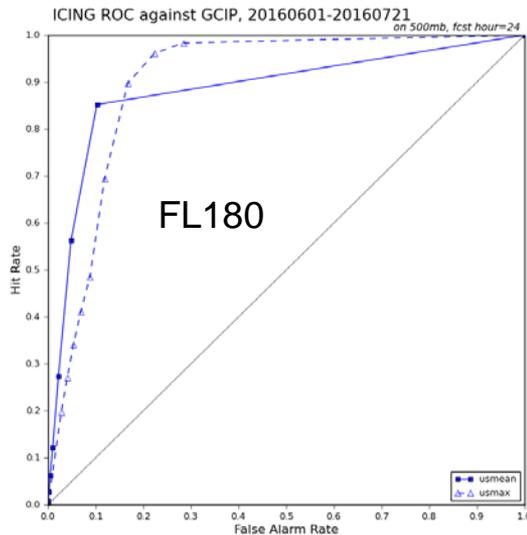## Reliability Diagram over Entire Global Domain

Fcst prob <50%, under confident
Fcst prob >50%, over confident, too aggressive!
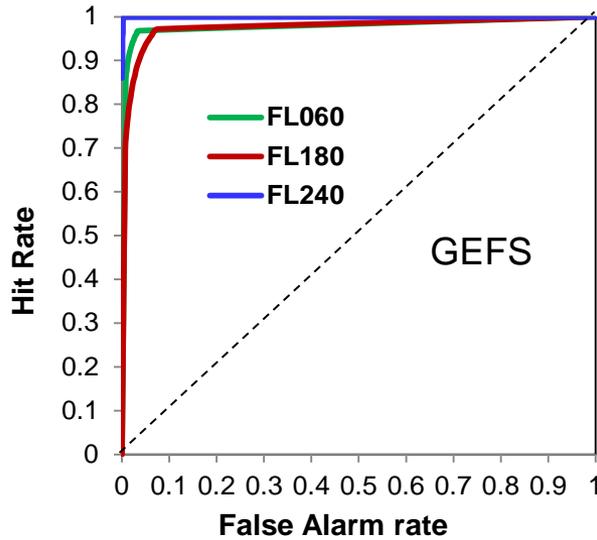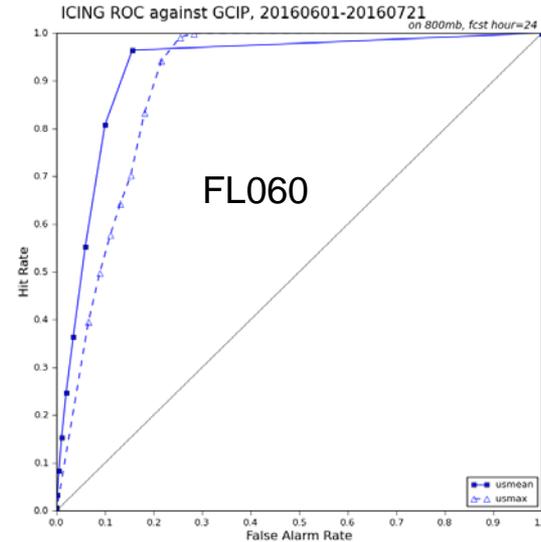
Solid: GFIP mean
Dash: GFIP max

Probability (% > thresholds)

Icing Potential (> IP thresholds)
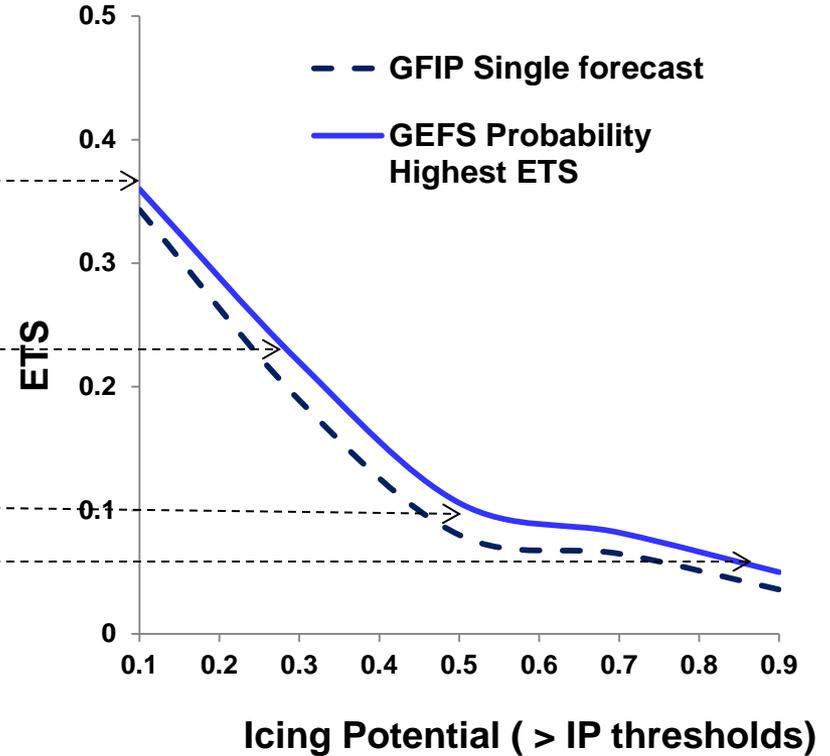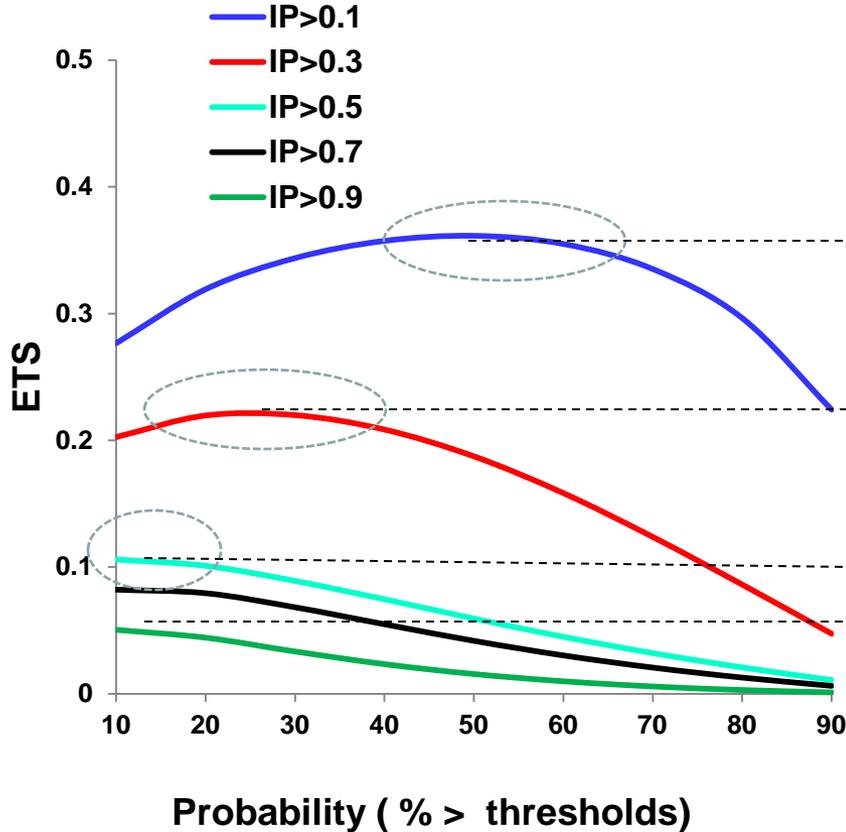
@ For light icing event (IP < or = 0.1), using probability 50% as threshold has best ETS and best reliability

@ For severe icing event (IP = or > 0.7), using smaller probability threshold (~ 20%) has best ETS, but may be under-confident (Forecast too conservative)

Future Work

- Implementation of icing severity in GEFS is scheduled June 2017

- Hope to evaluate it in same way as GEFS icing potential
  ~ Challenge: no reliable analysis of icing severity as GCIP

Summary

❑ GEFS icing potential forecast was implemented in 2016

❑ More skillful than single model forecasts

❑ Under-spread implies the forecasts are too confident, particularly at lower levels

❑ Errors decreased with height with the largest errors at lower levels

❑ Forecasts are better over SH than NH

❑ Very good ROC skill (hit rate >> false alarm rate)

❑ Reliability plot shows too little confidence for lower probability events and too much confidence for higher probability events

❑ Adjust probability threshold for different icing potential events to get better forecast skill