Recent Developments in Microphysical Modeling

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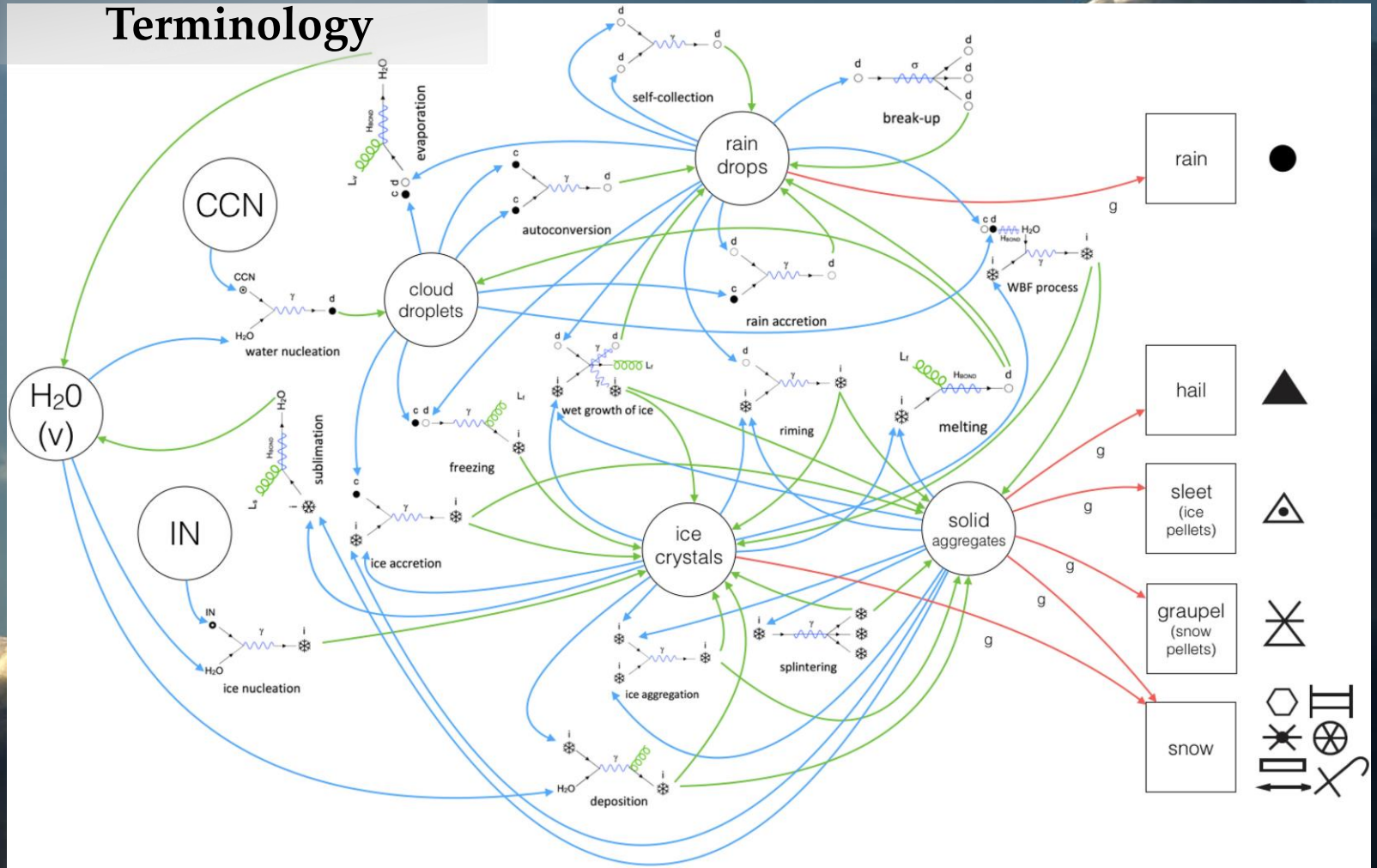
ICICLE participants

NCAR

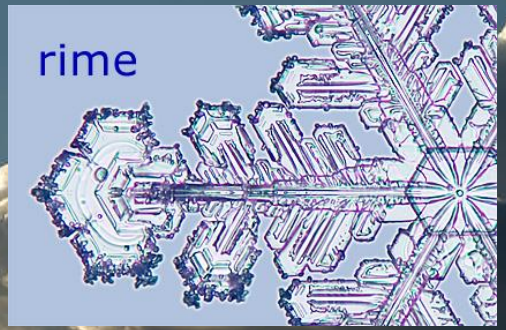
Outline

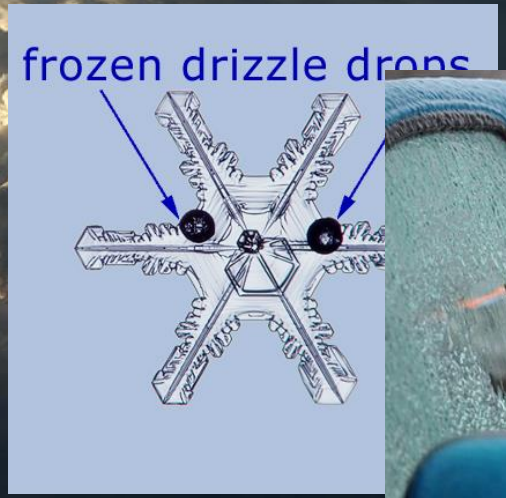
- **Recent Research**
  - ICICLE Field Project
  - Stochastic Parameter Perturbations
- **Upcoming Improvements**
  - Melting Snow
  - Variable-density Graupel/Hail

Terminology



Motivation

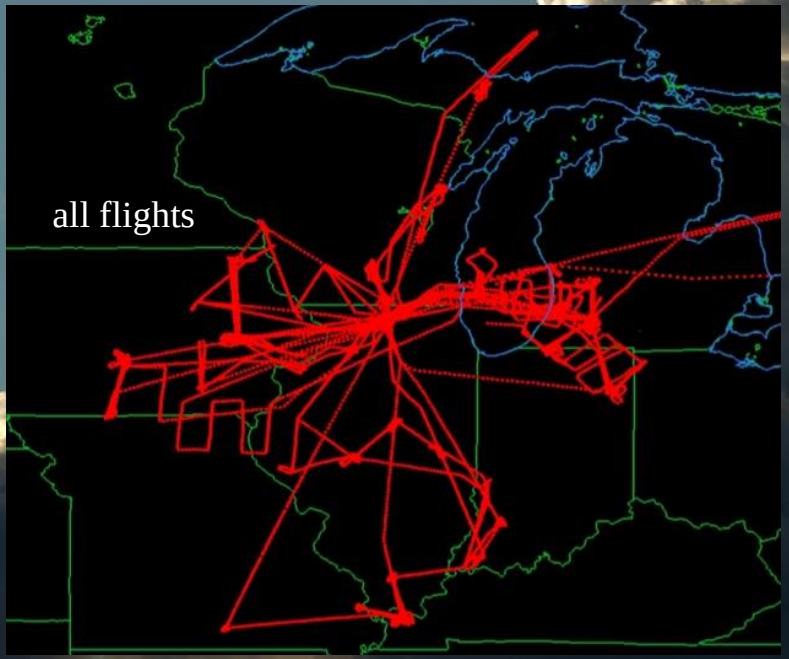




ICICLE

In-Cloud ICing and Large-drop Experiment

- 27Jan-05Mar 2019
- FAA / NCAR / ECCC / NRC / LEA / +++



- Hit target of ~110 hr in 5.5 weeks
  - ~83 hr of sampling (29 ferry/other)
  - ~49 hr in icing
- >20 hours in "small-drop" icing
  - ~6 hr in relatively high MVD and/or high LWC
- >20 hours in FZDZ, ~6 hours in FZRA (a lot!)
  - Most FZDZ found aloft
  - Less than half seemed to reach the surface
  - Most FZRA *did* extend to the sfc
  - Significant amount was in mixed phase

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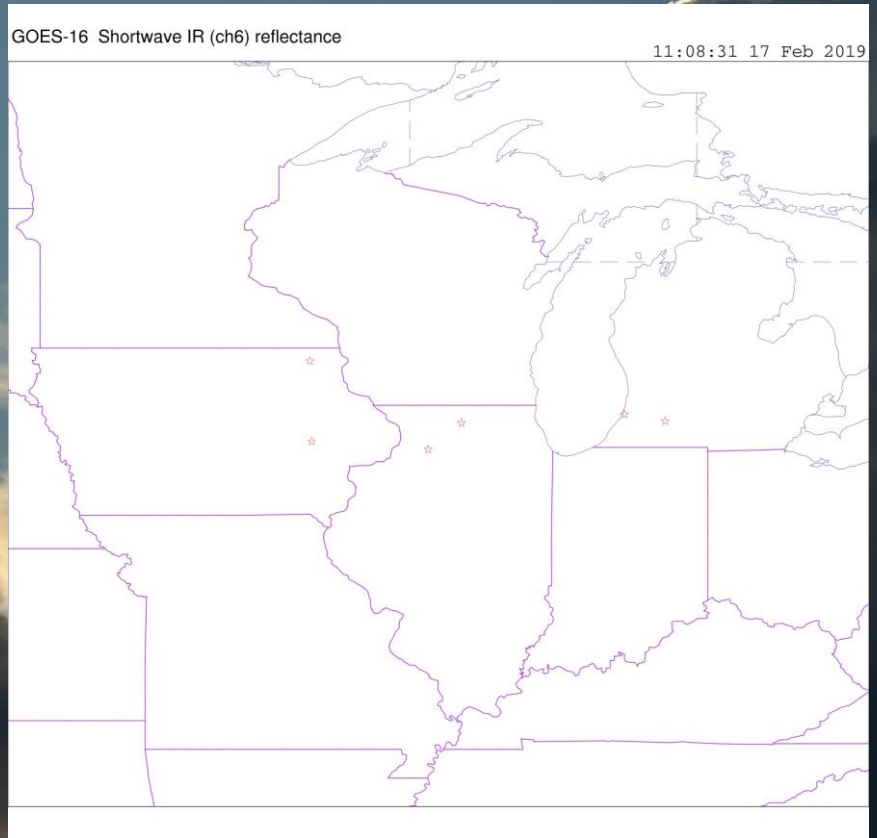
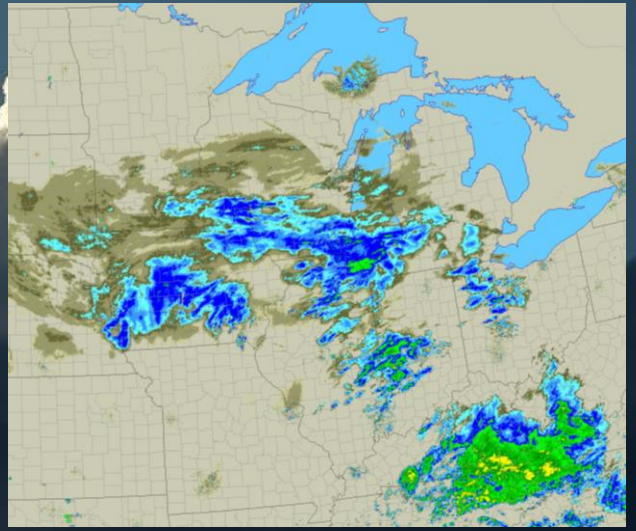
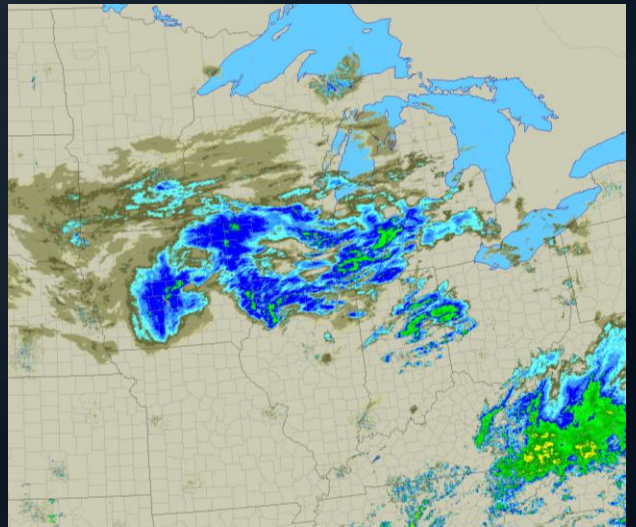
- FZDZ does not look like *convection*



1245 UTC



1500 UTC



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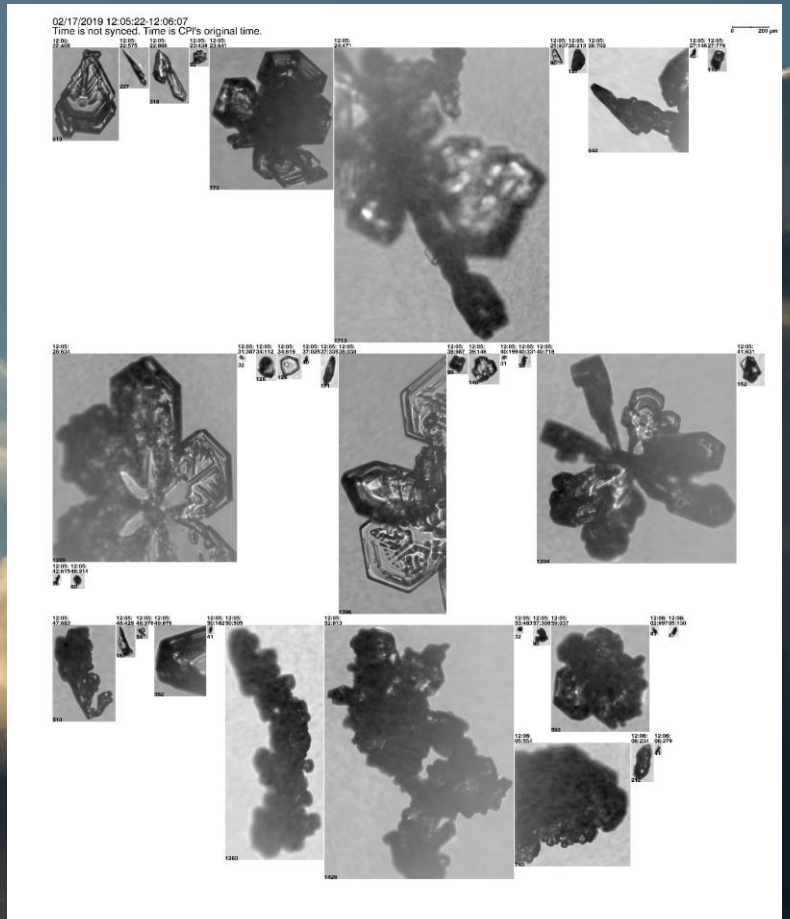
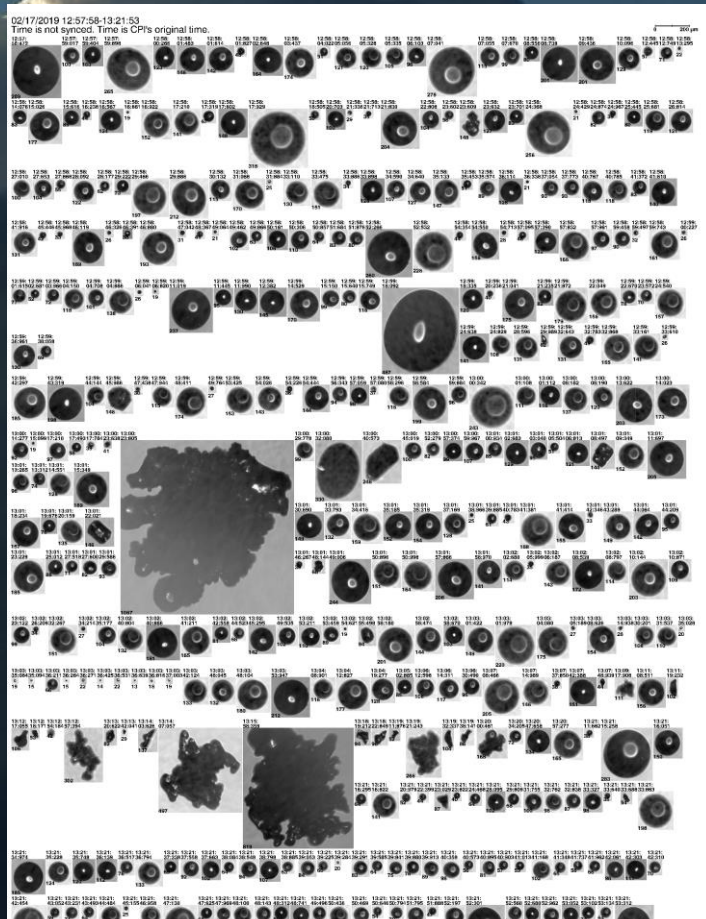
minutes after takeoff



50 minutes later



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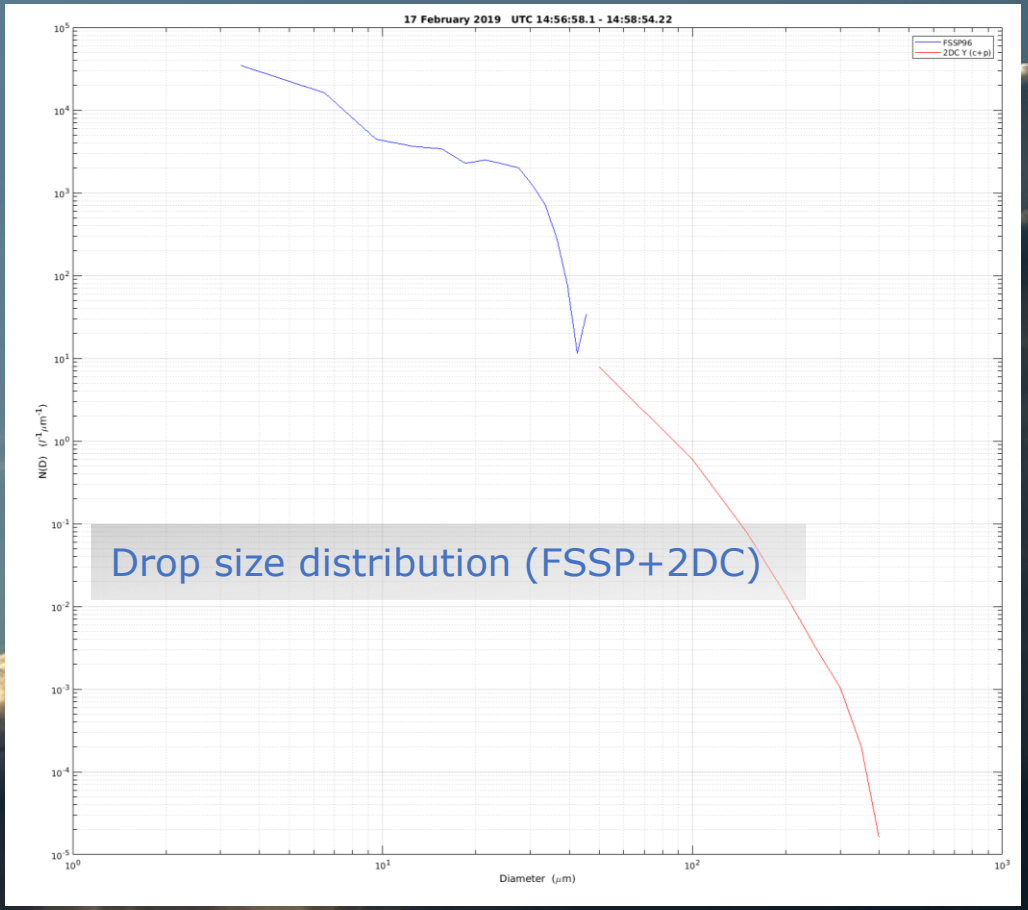
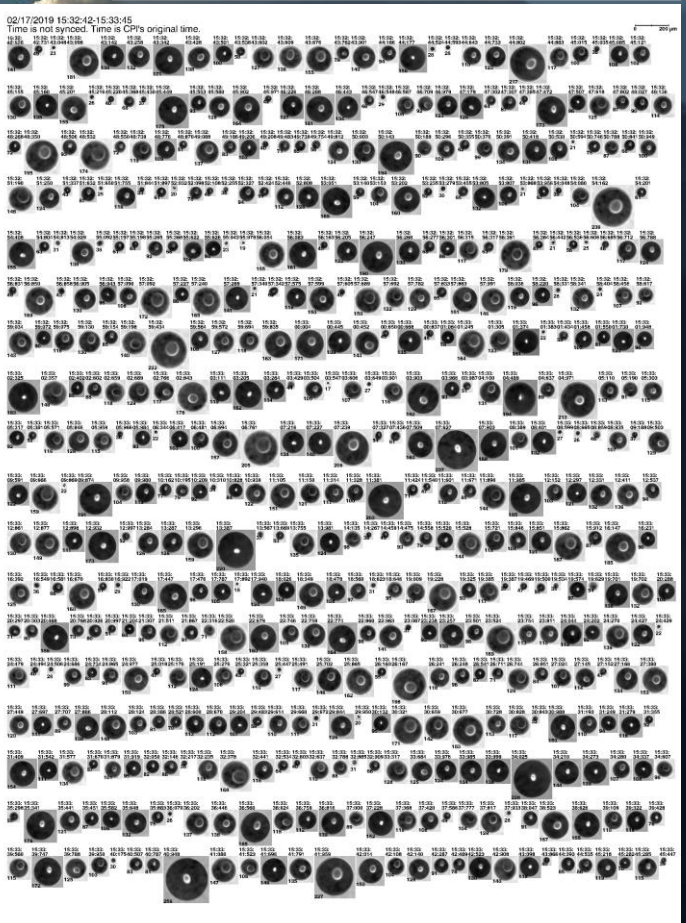


Drop size distribution (FSSP+2DC)

Cloud Particle Imager (CPI)



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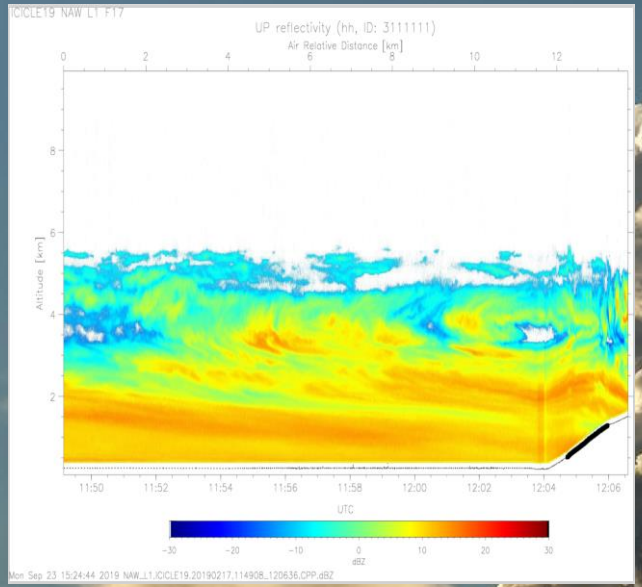
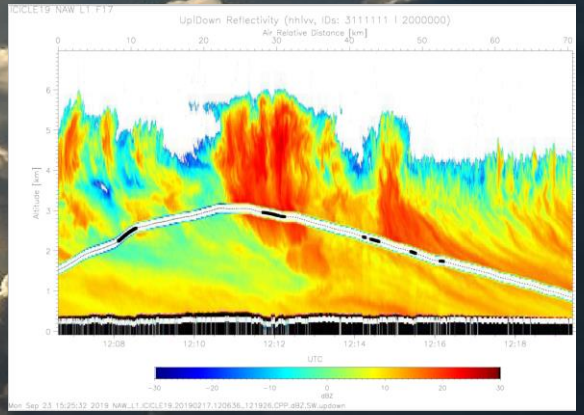
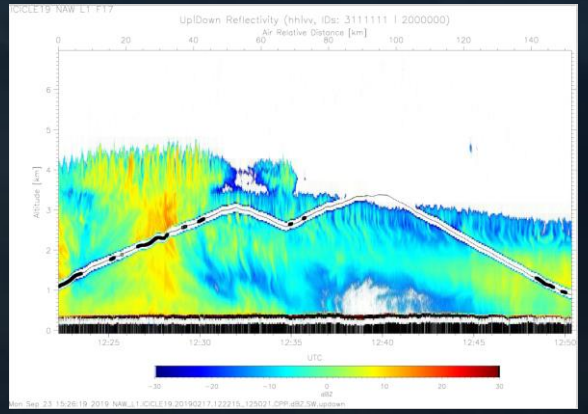
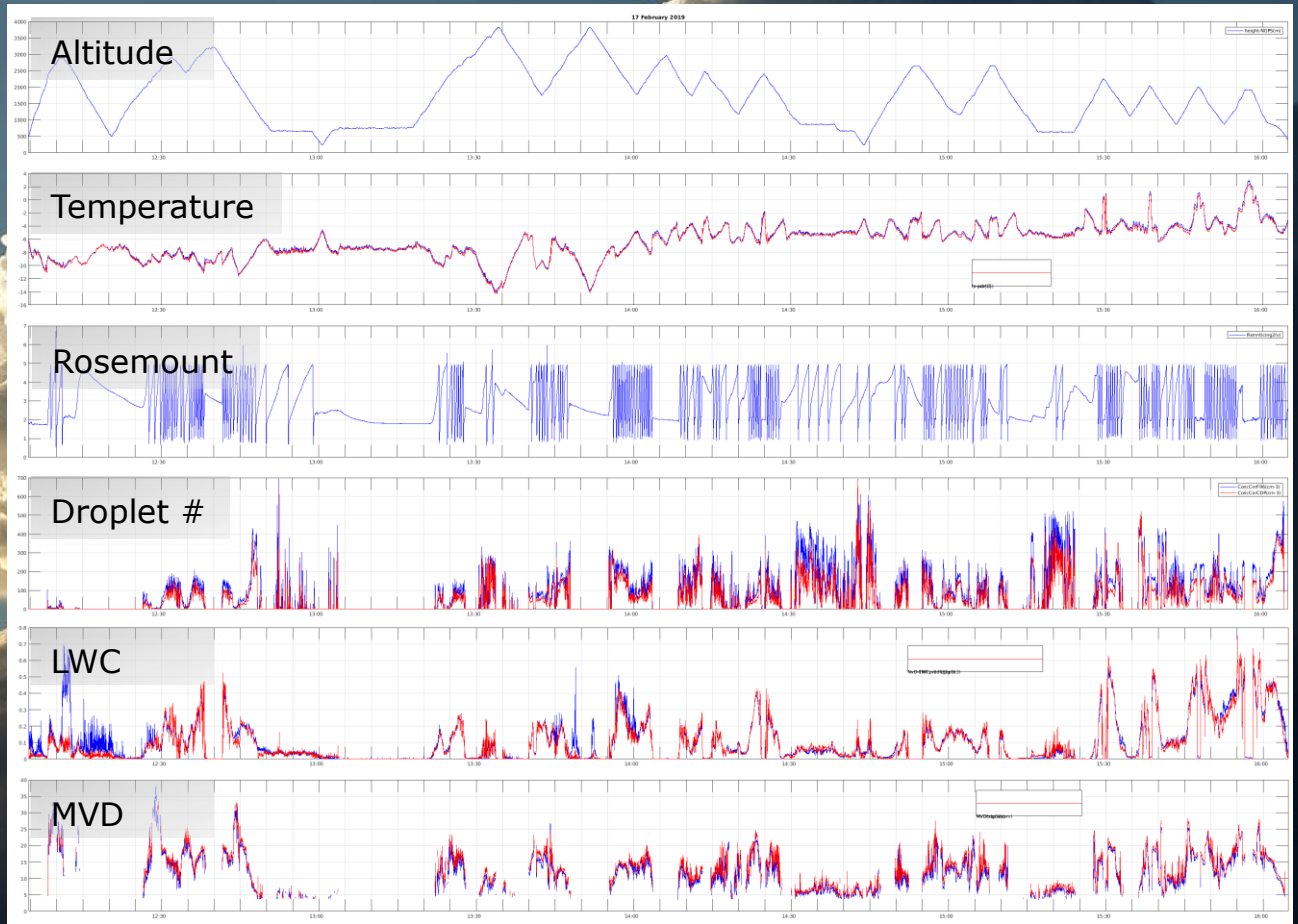




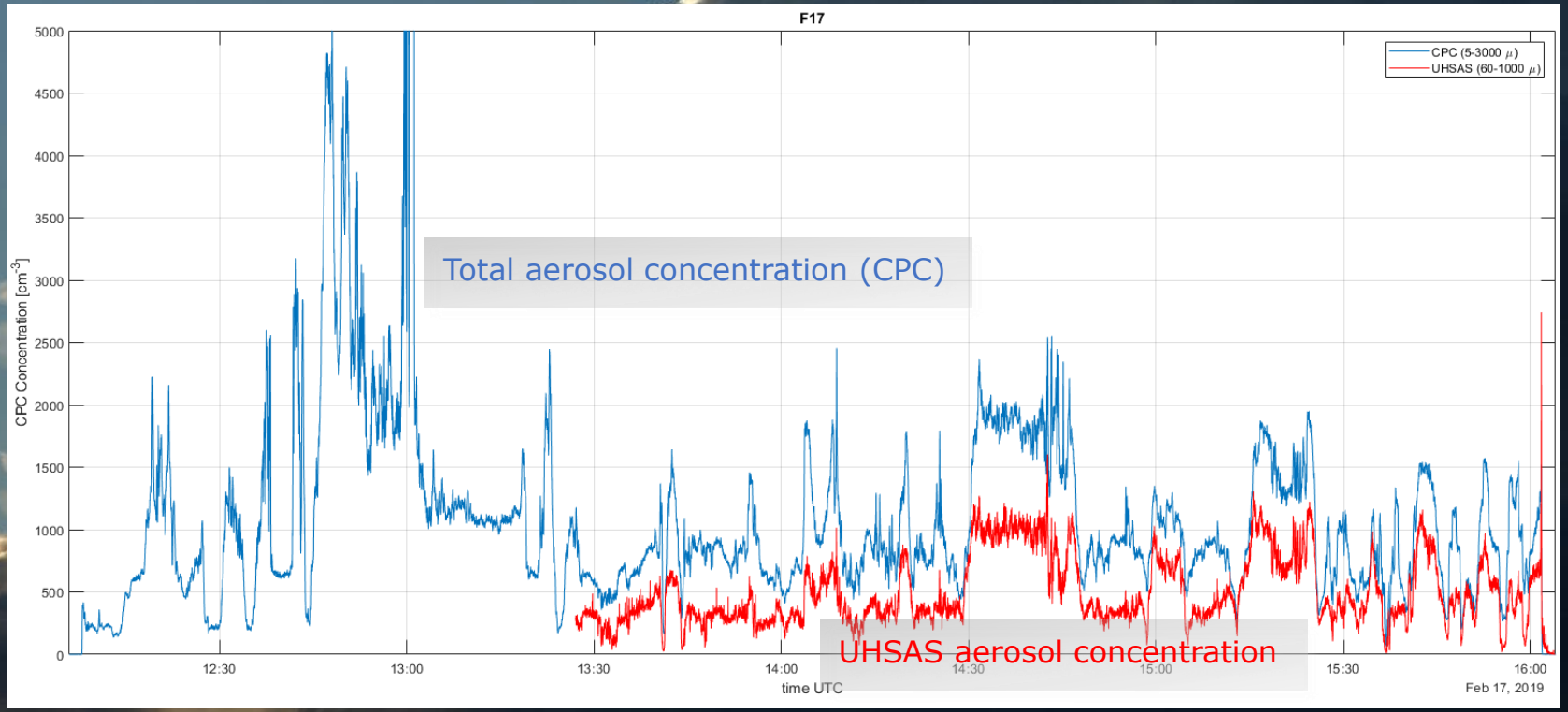


Convair580 (prelim. data)



preliminary data thanks to Alexei Korolev

Convair580 (prelim. data)

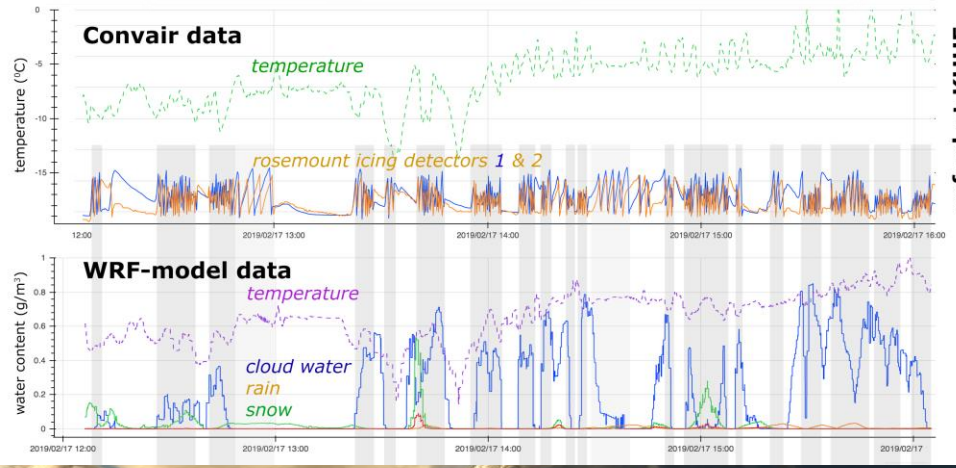


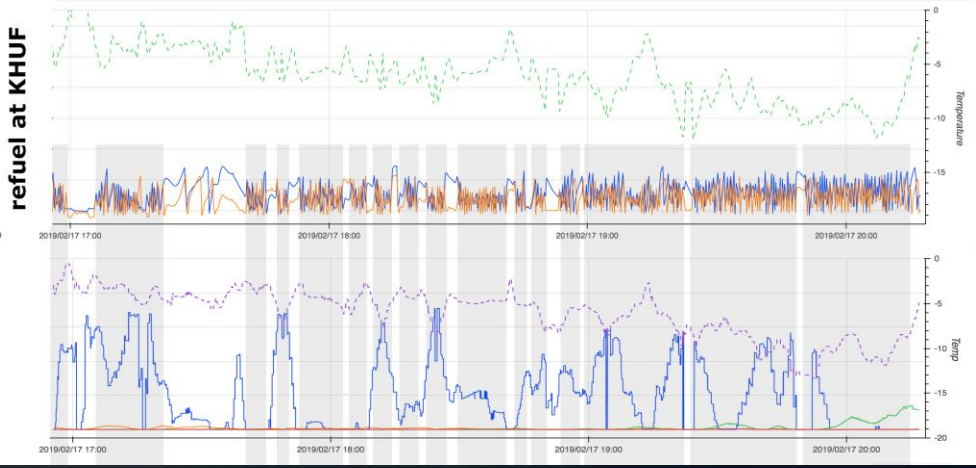
preliminary data thanks to Leonid Nichman

WRF simulation (600m) vs. Obs

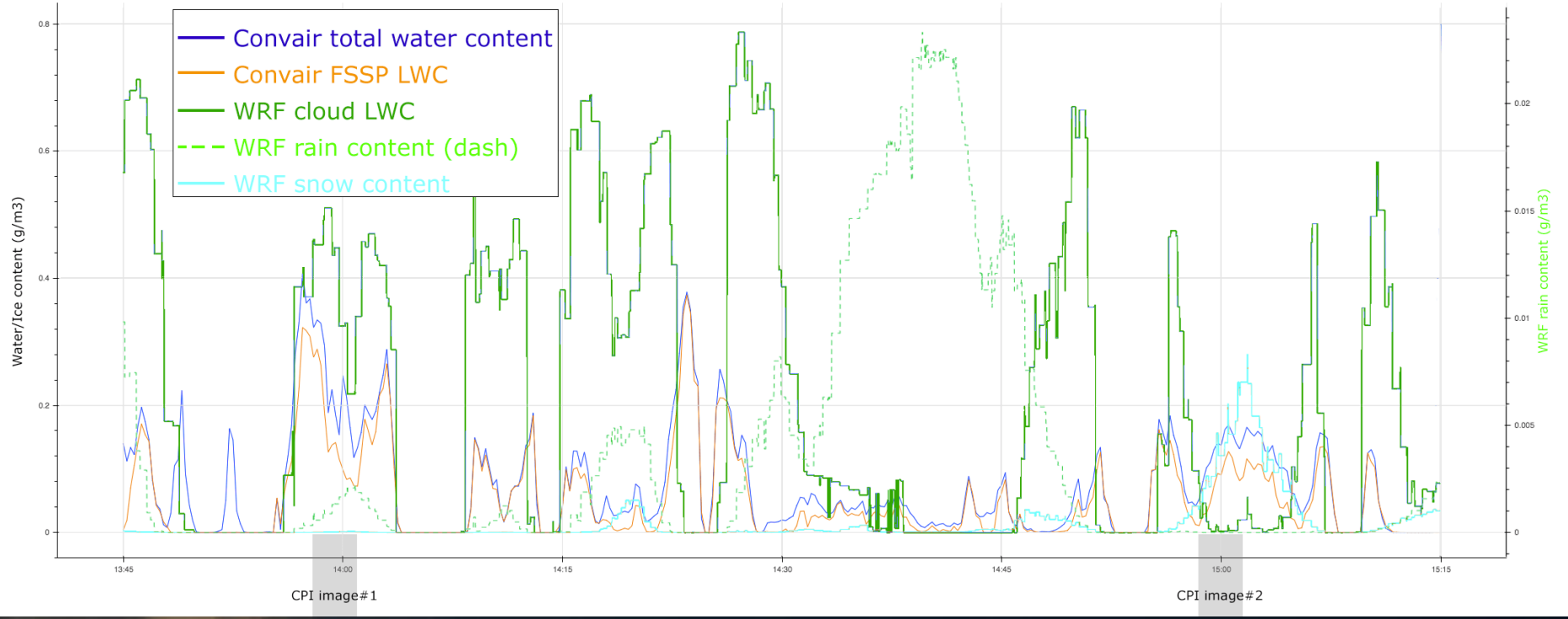
Flight #17

Flight #18

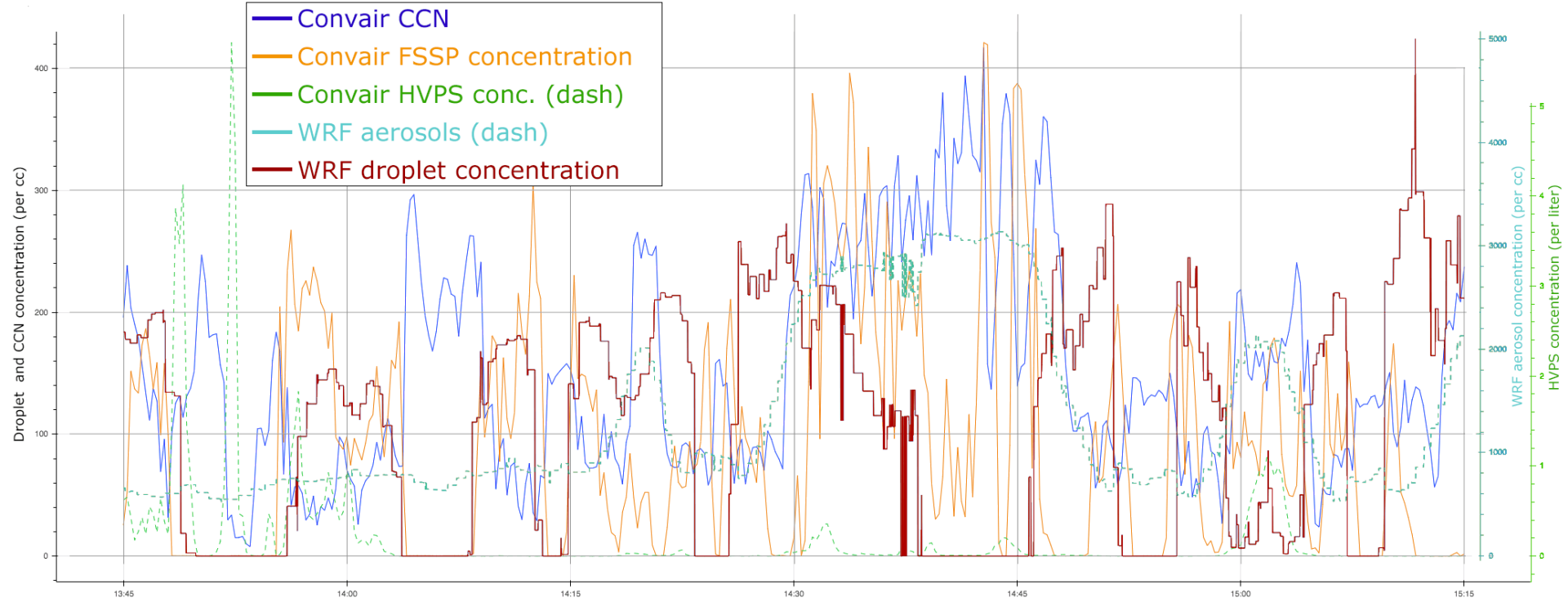




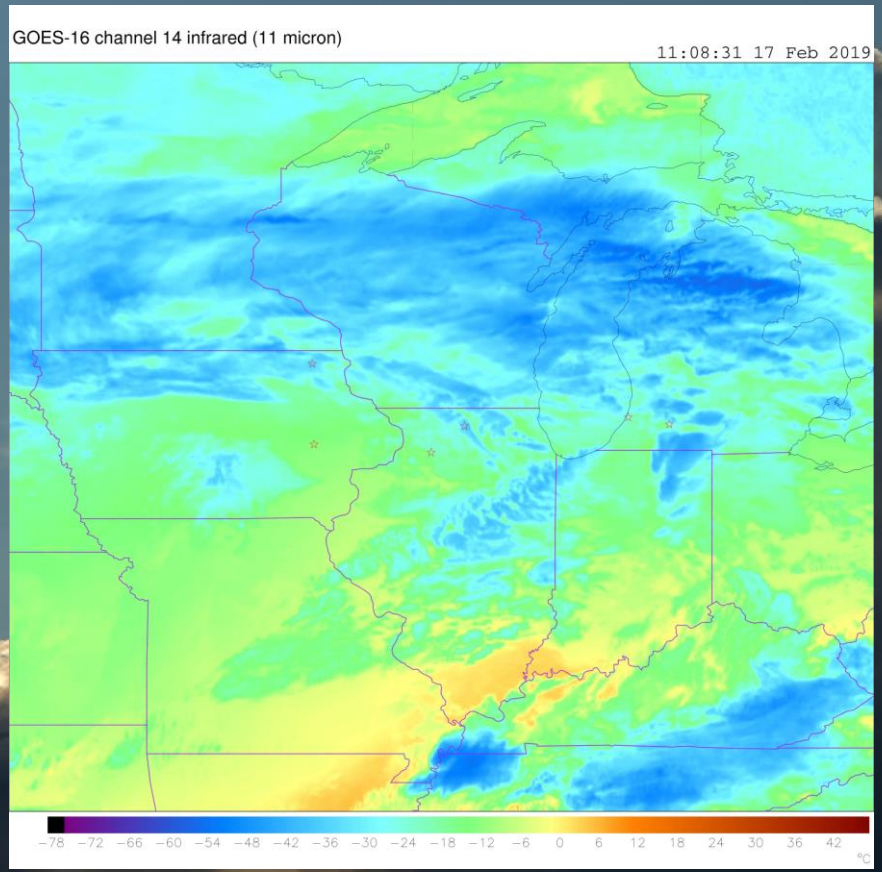
WRF simulation (600m) vs. Obs

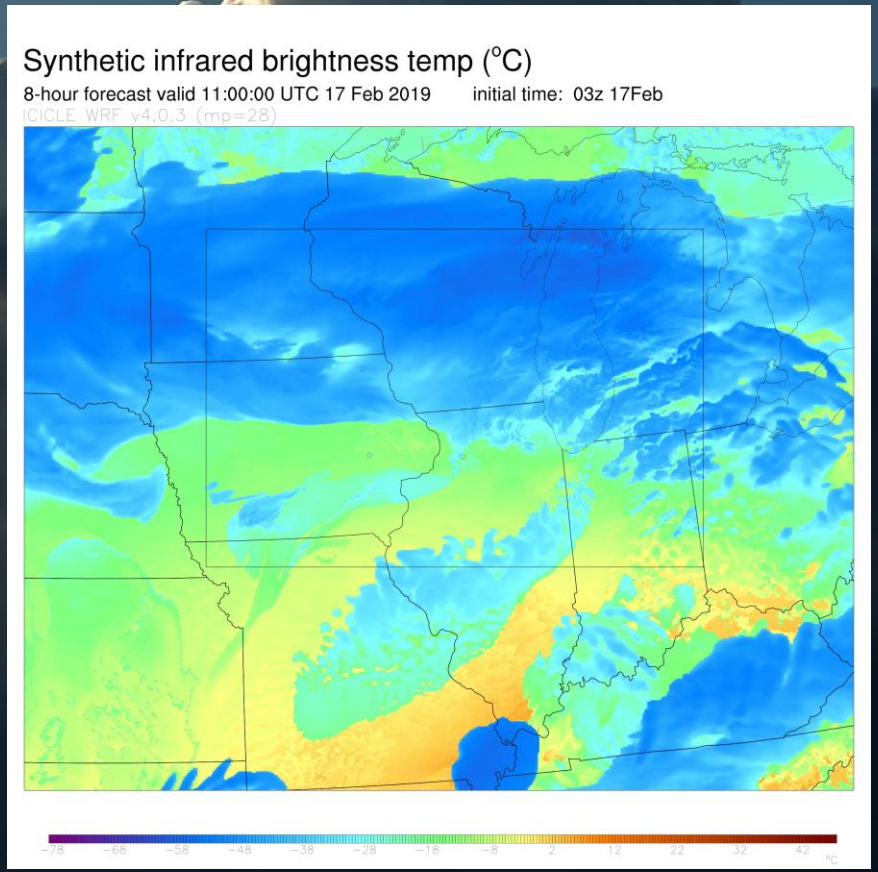


WRF simulation (600m) vs. Obs

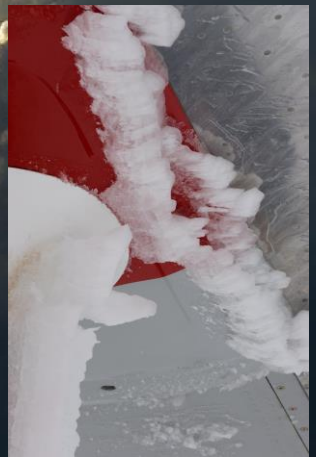


WRF simulation (600m) vs. Obs





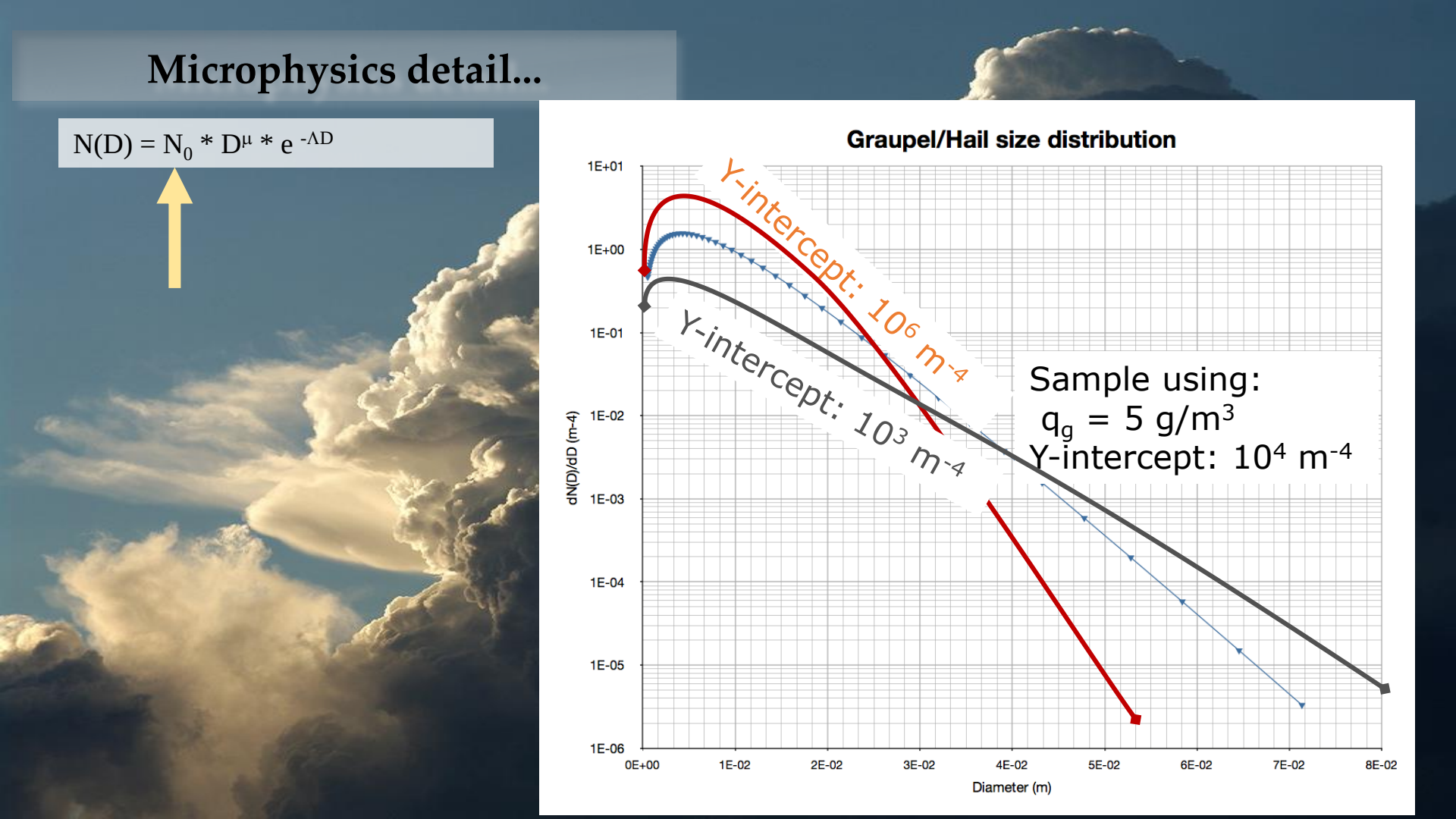
Landing @KRFD 2030UTC



Stochastic Parameter Perturbations (SPP)

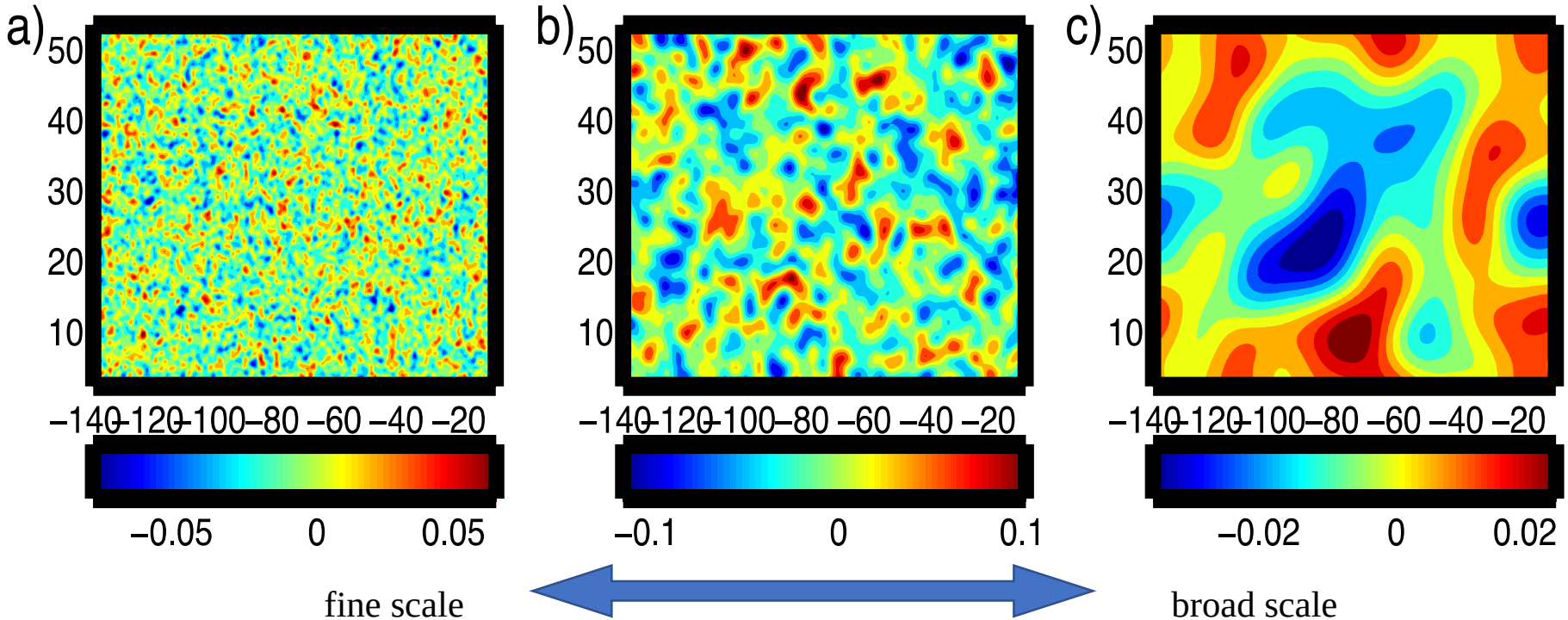
Microphysics detail...

$$N(D) = N_0 * D^{\mu} * e^{-\Lambda D}$$



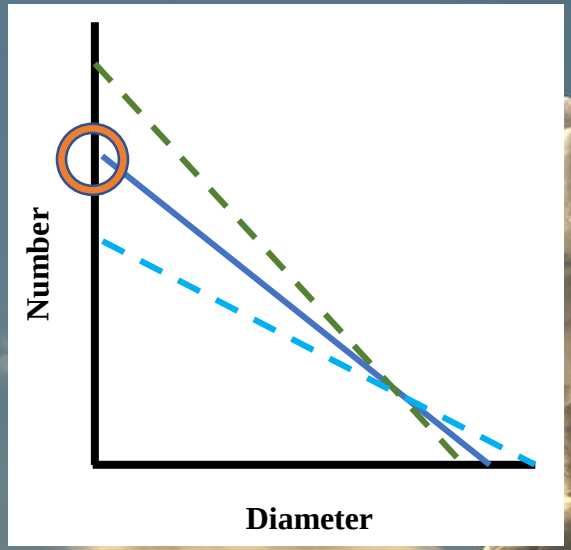
Stochastic Parameter Perturbations (SPP)

Example random perturbation patterns
User defined: magnitude, spatial, and temporal time scales



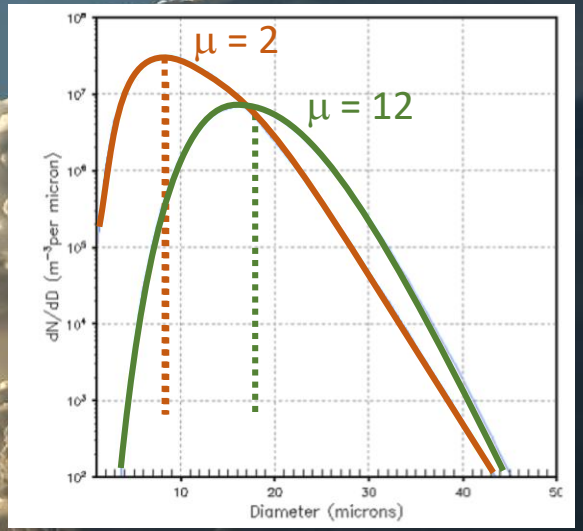
Alterations to microphysics scheme

A.) Graupel Y-intercept parameter



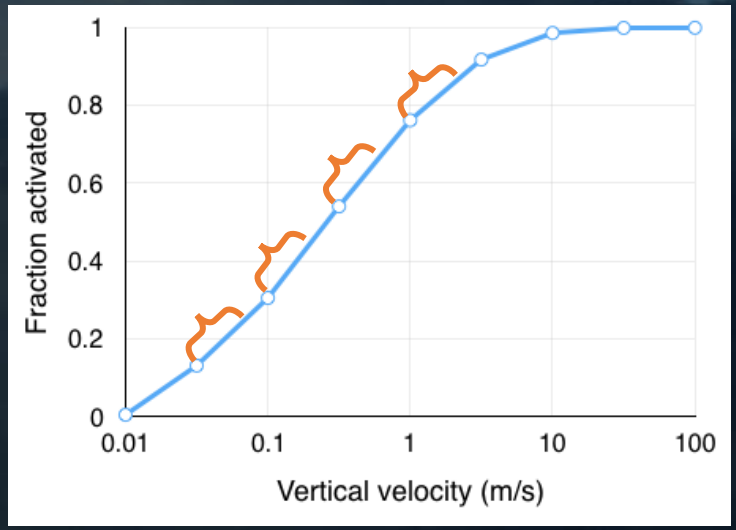
+/- 1.5 orders of magnitude (m^{-4})

B.) Cloud water shape parameter



+/- 3 always constrained [2,15]

C.) Cloud Condensation Nucleation

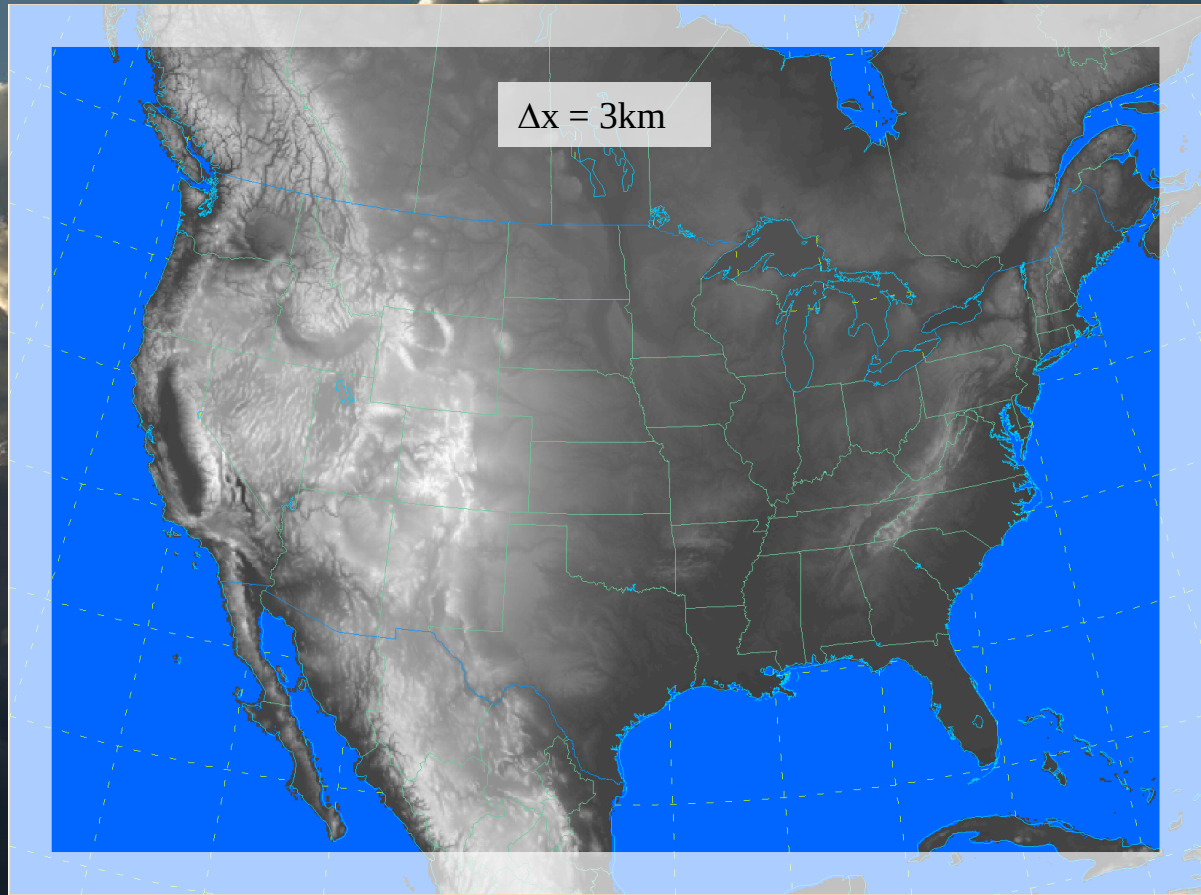


W perturbed up to + 0.35 m/s

Experiment design

WRF (v3.9.1.1+) over CONUS configured nearly same as HRRR

- May 2017: 5 cases
- Jan 2018: 5 cases
- SPP-MP ensemble of 5 members
- SPP-MP-Inverse pattern tests
- ”Control” without SPP-MP
- **White noise** ensemble of 4 members
  lowest 800 meters Theta 0.05K perturbations only at initial time

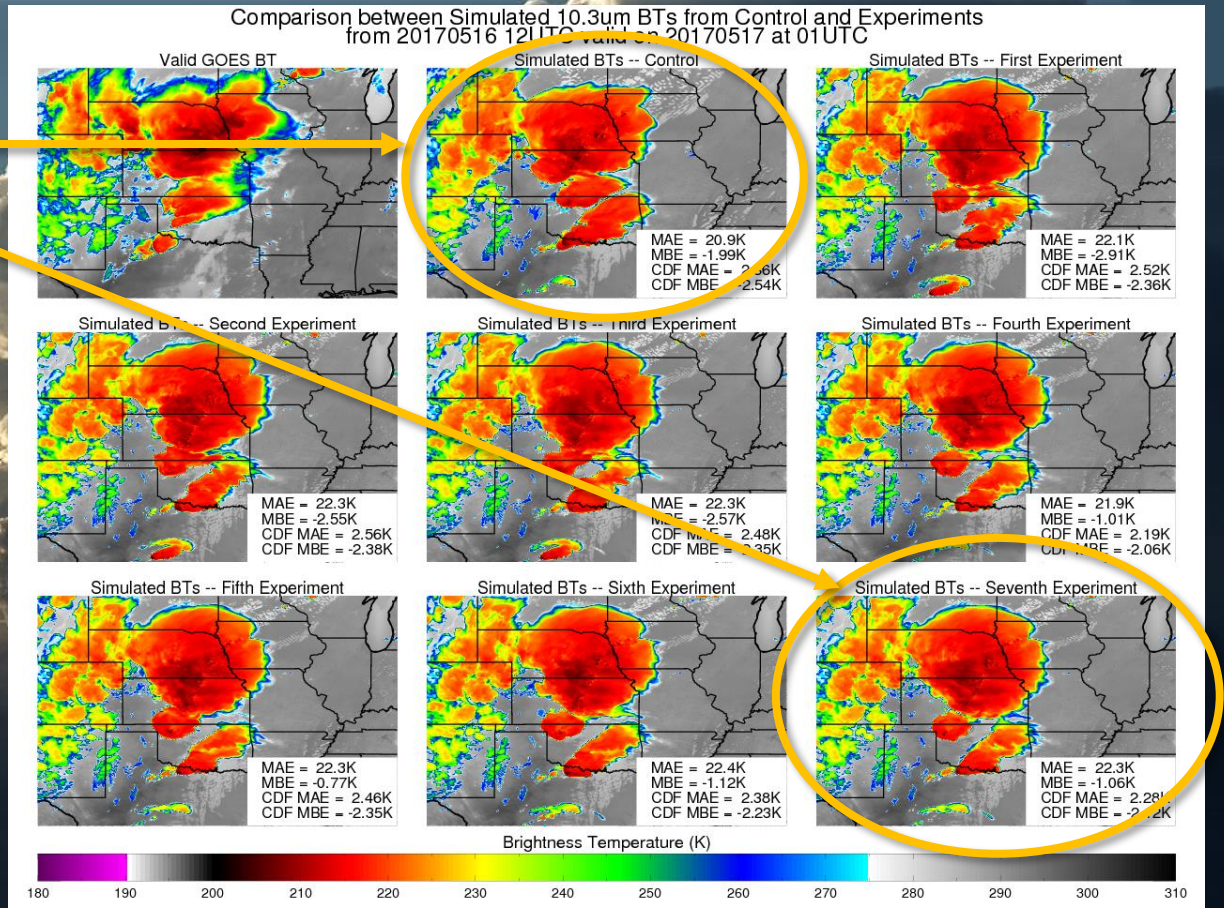


Application Testing: Hazardous Weather Testbed

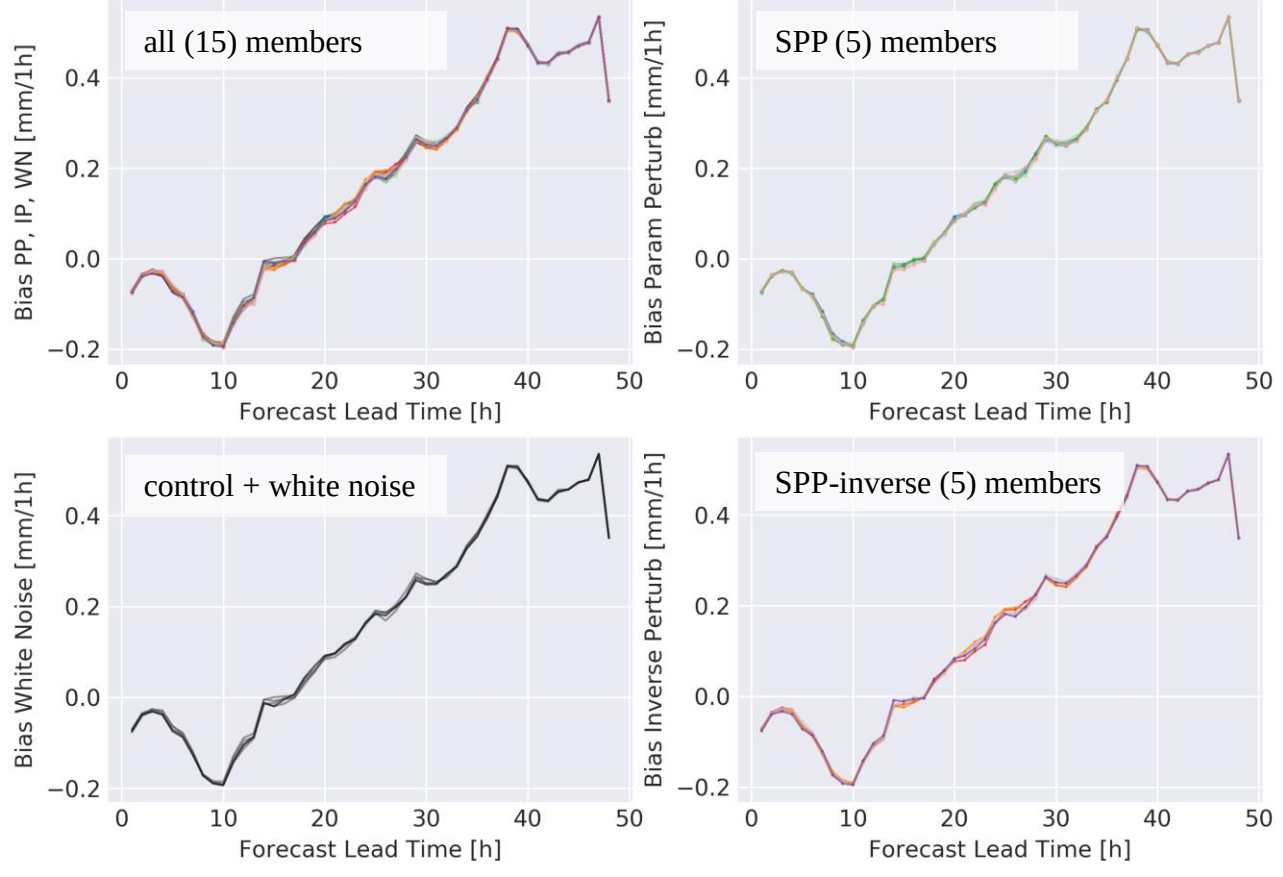
OU-CAPS 2017 Spring Experiment

Control: no SPP

SPP_MP = 7 (all)



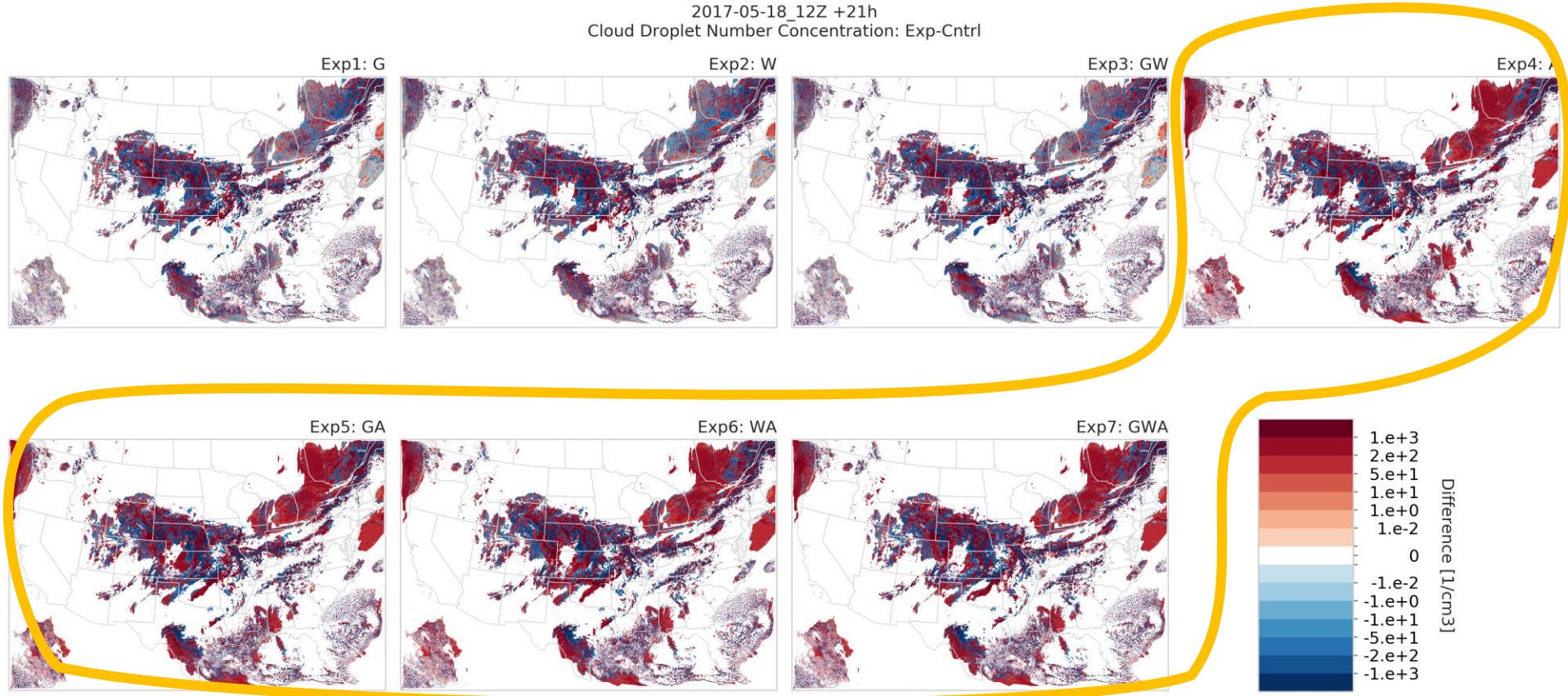
SPP, SPP-Inverse, White-noise



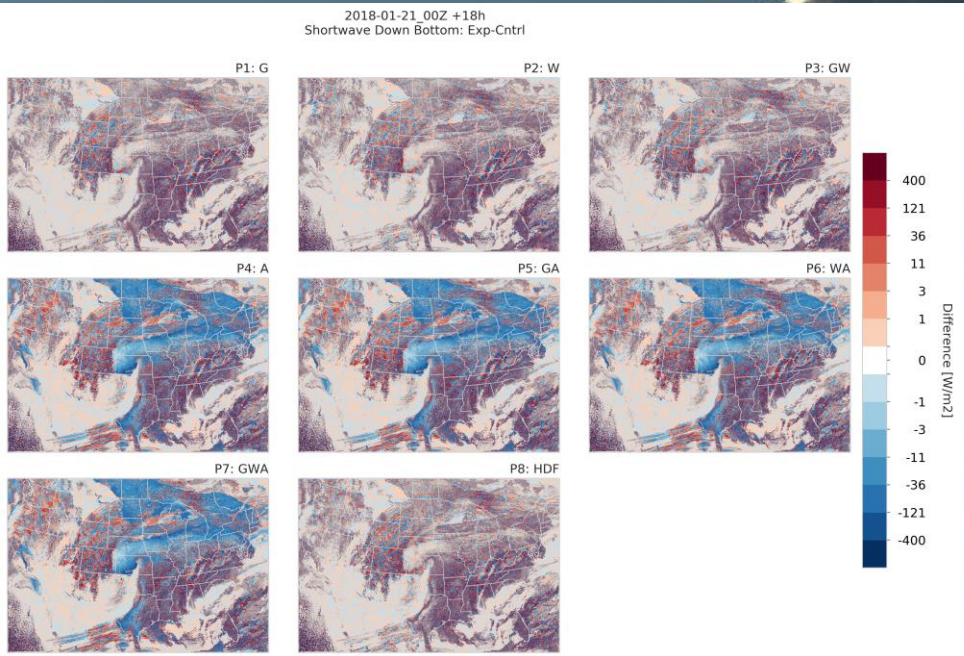
Variables evaluated

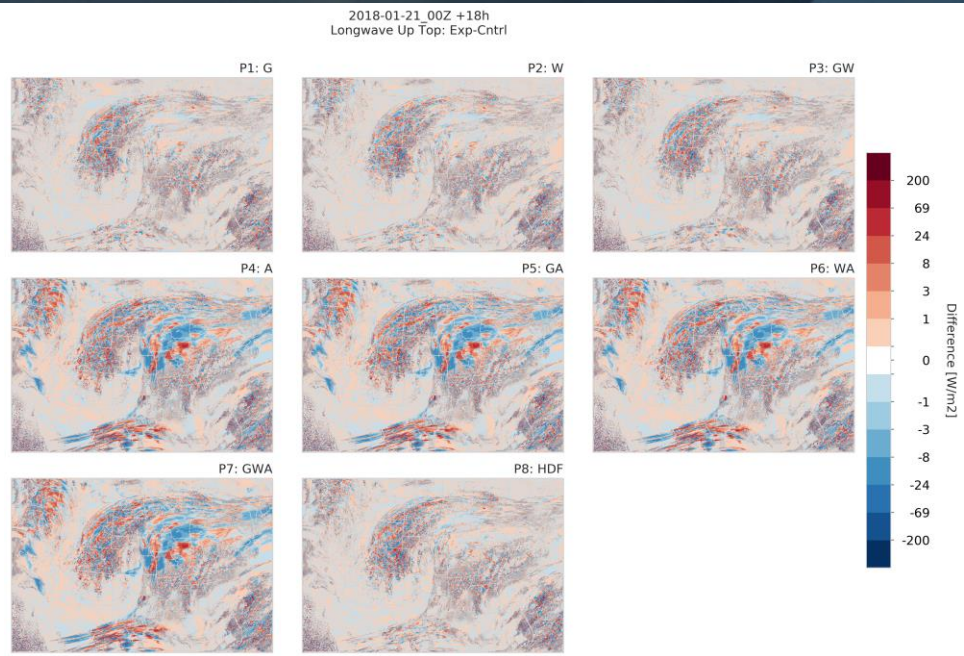
- Satellite brightness temperatures (IR)
- Shortwave and longwave radiation
- Radar reflectivity
- QPF – quantitative precip forecasts
- Maximum hail size (aloft & sfc)
- Direct hydrometeor quantities
  water content: cloud water, rain, snow, etc.
  number concentrations
- + Various MODE statistics

Testing: added CCN makes more cloud droplets?

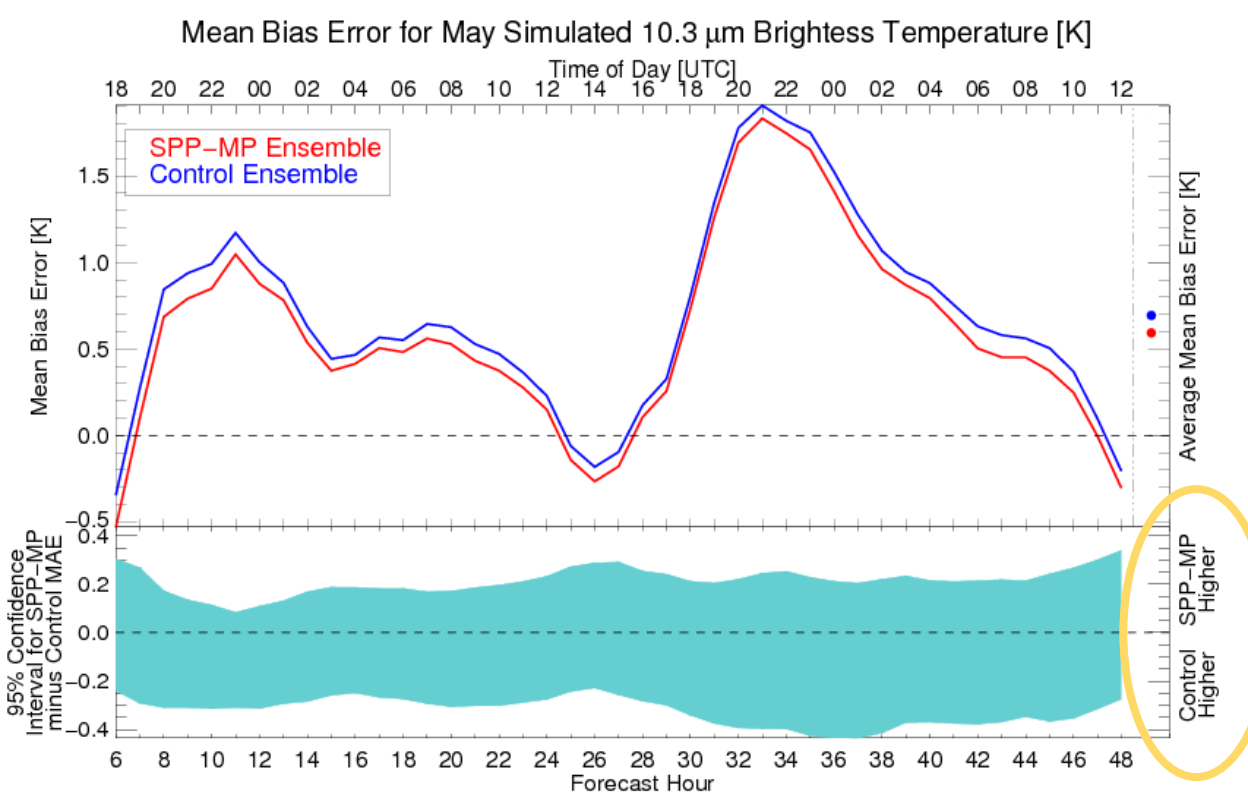


Climate implications: how many W/m^2?

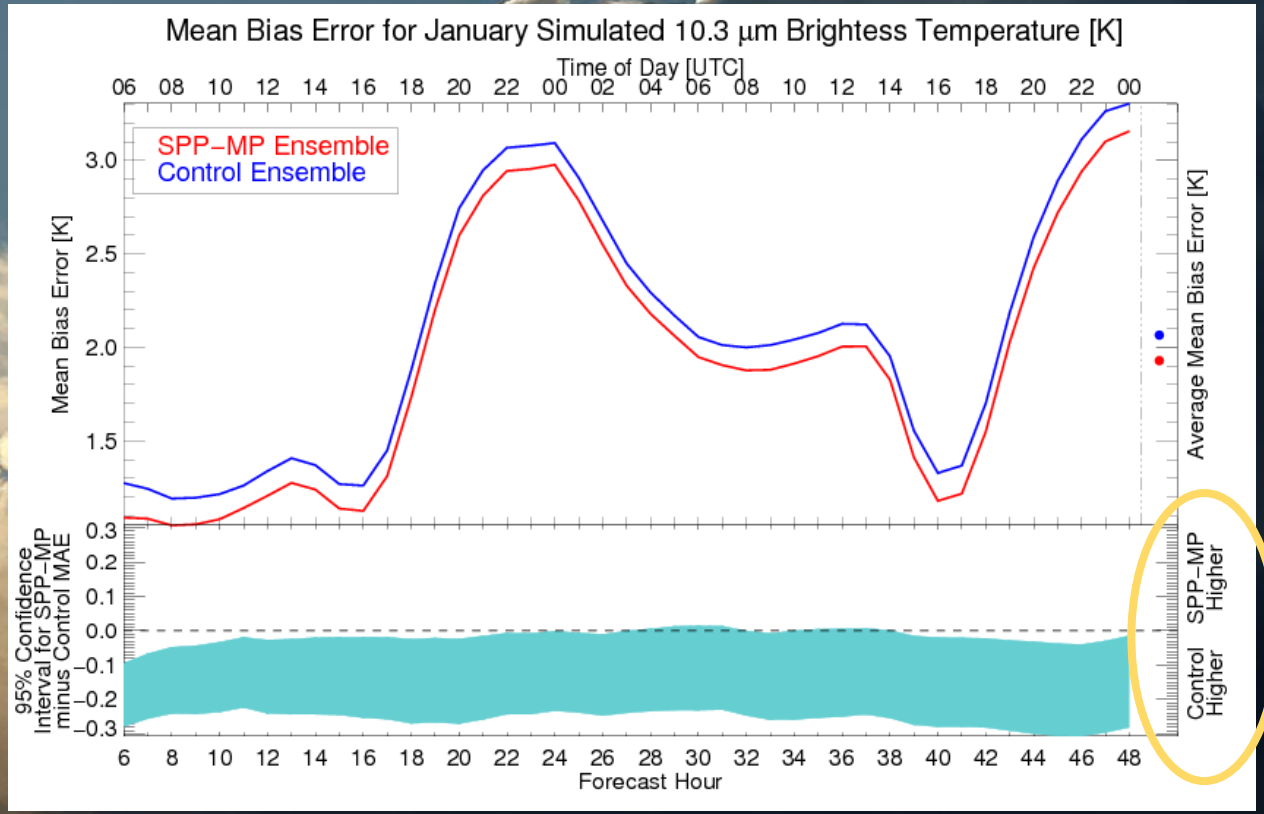




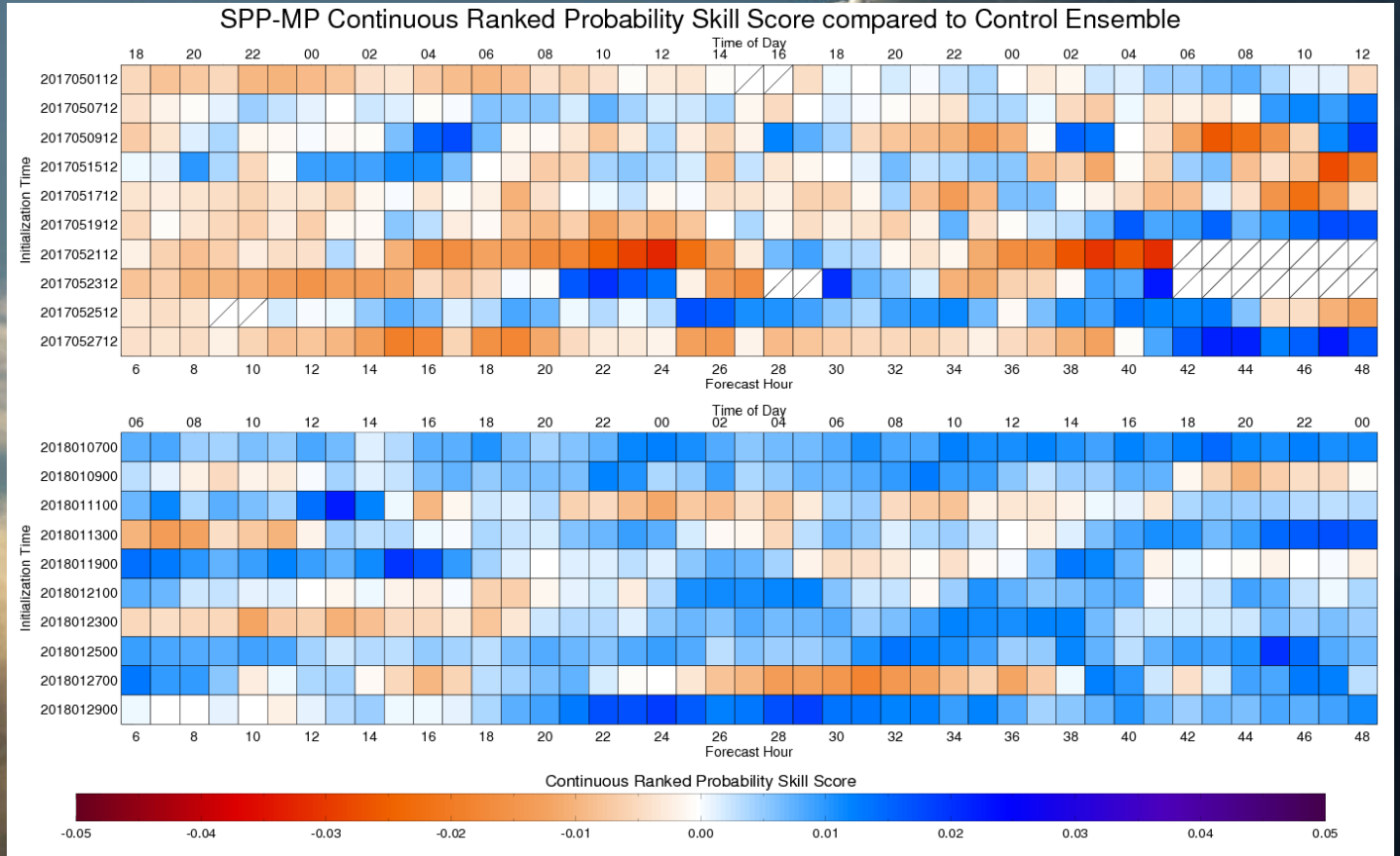
Analysis using GOES-16 IR (May2017, 5 dates)



Analysis using GOES-16 IR (Jan2018, 5 dates)



Skill scores May2017 and Jan2018 (GOES-16 IR)



Conclusions, thoughts, future work

- Stochastic perturbations within microphysics scheme address known parameter uncertainties
- Early results show promise towards improving spread-skill relationship for precipitation
- SPP-MP together with SPP-LSM and SPP-PBL have far greater total impact
- It is important to use multiple variables and datasets for verification!

Acknowledgements

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