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Using WINTRE-MIX observations to evaluate high-resolution forecast models

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WINTRE-MIX 2022

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https://www.eol.ucar.edu/field_projects/wintre-mix

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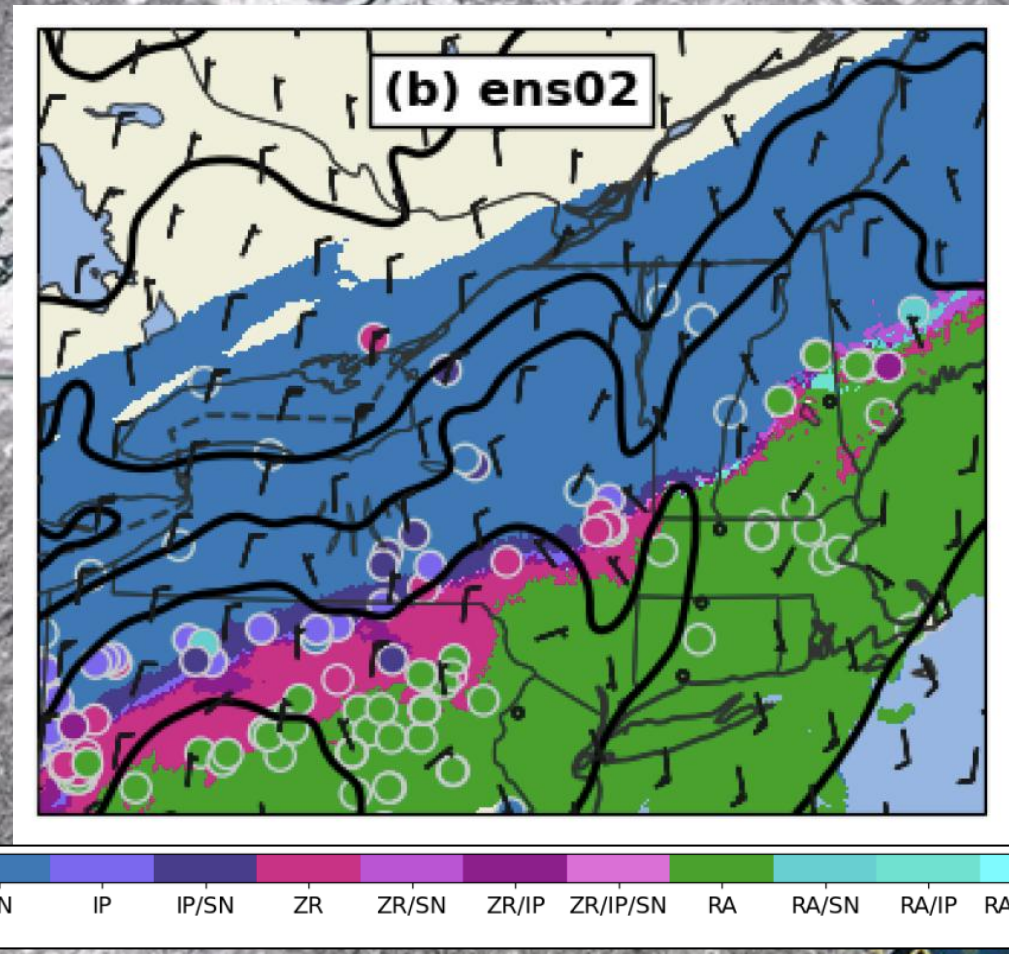
High-resolution numerical forecasts of p-type

Overview

Numerical weather prediction (NWP) models run at high-resolution are a crucial tool for p-type forecasting

- Horizontal grid spacing ~3km, comparable with features of interest
- Can explicitly represent important effects of terrain and storm features
- Sophisticated treatment of cloud/precipitation, turbulence, and land surface processes
- P-type can be diagnosed from model output



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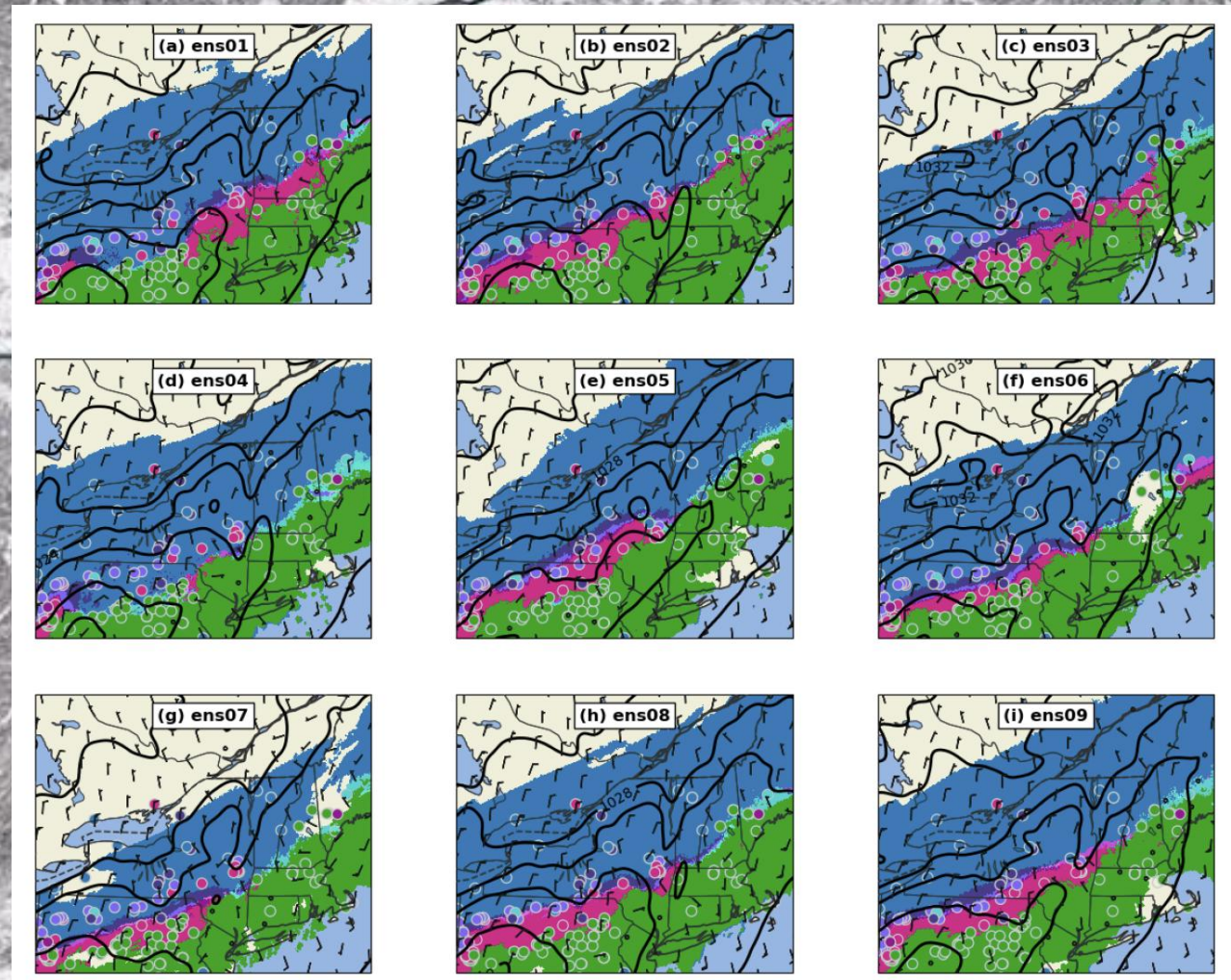
High-resolution numerical forecasts of p-type

Using ensembles for probabilistic forecasting

- **Ensembles**: suite of distinct model forecasts used to map out range of possible outcomes

- Ensemble **members** may differ in
  - *starting conditions*
  - *numerical approximations*
  - *representation of uncertain processes*

- Ensembles are crucial tools for generating **probabilistic forecasts**



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High-resolution numerical forecasts of p-type

Using ensembles for probabilistic forecasting

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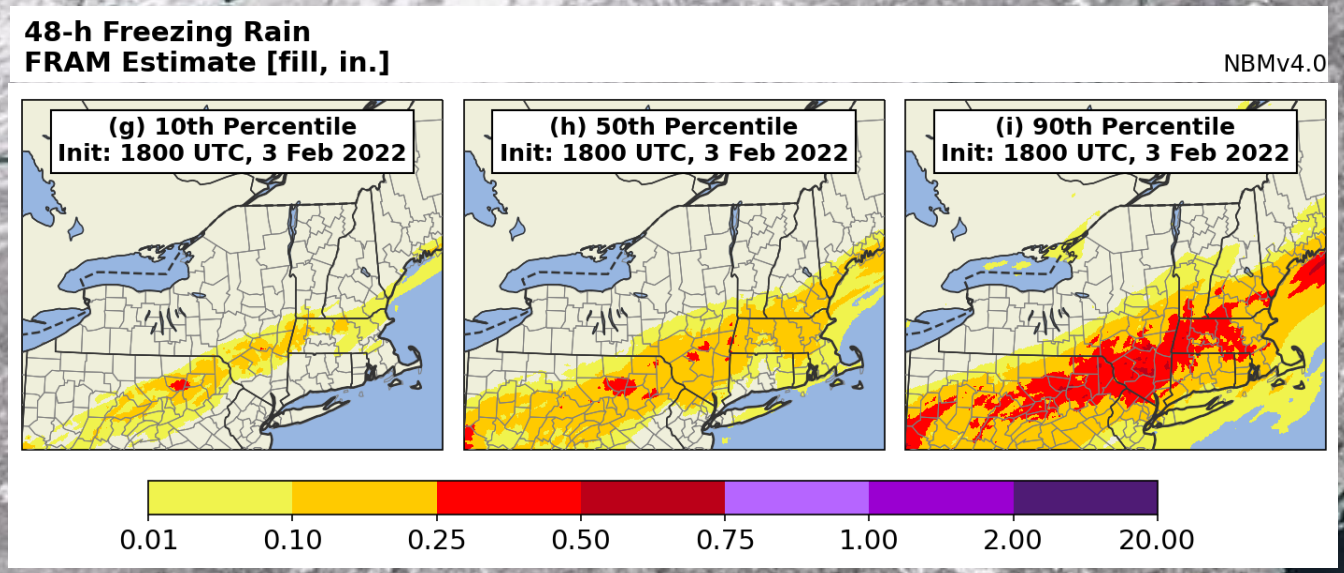
- Ensembles are crucial tools for generating **probabilistic forecasts**



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High-resolution numerical forecasts of p-type

The HREF and HRRRE ensembles

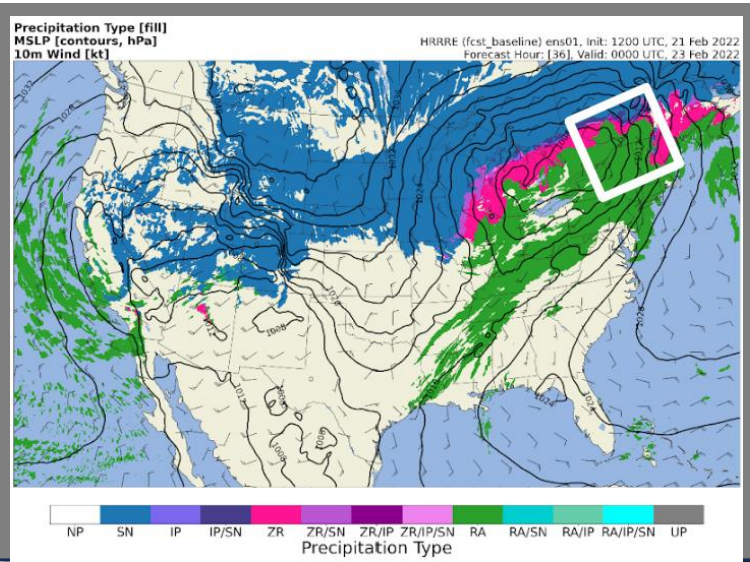
High-Resolution Ensemble Forecast system (HREF)

- 3-km horizontal grid spacing
- Operational NWS model
- 10 members differ in:
  - *Initial and boundary condition source*
  - *Initialization time*
  - *Dynamical core*
  - *Physics parameterizations (e.g., clouds, turbulence)*
- Members may have biases relative to each other

Member	IC's	LBC's	PBL	Microphysics
HRW ARW	RAP	GFS -6h	YSU	WSM6
HRW FV3	GFS -6h	GFS -6h	GFS EDMF	GFDL
HRW NSSL	NAM	NAM -6h	MYJ	WSM6
HRRR	RAP -1h	RAP -1h	MYNN	Thompson
NAM Nest	NAM	NAM	MYJ	Ferrier-Aligo

High-Resolution Rapid Refresh Ensemble (HRRR-E)

- 3-km horizontal grid spacing
- Experimental model, run by NOAA-GSL
- 9 members are differ in:
  - *Perturbations to initial and boundary conditions*
  - *Perturbations to physics parameterizations*
- Members are “equally likely”



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High-resolution numerical forecasts of p-type
Questions

- *How well do modern high-resolution ensembles predict winter p-type?*
- *Do ensembles (or individual members) have systematic biases that we should consider?*
- *How can ensembles be improved?*

Use WINTRE-MIX data and archived high-res. forecasts to examine these
(will show "Intensive Observing Period #5 (IOP5) here)

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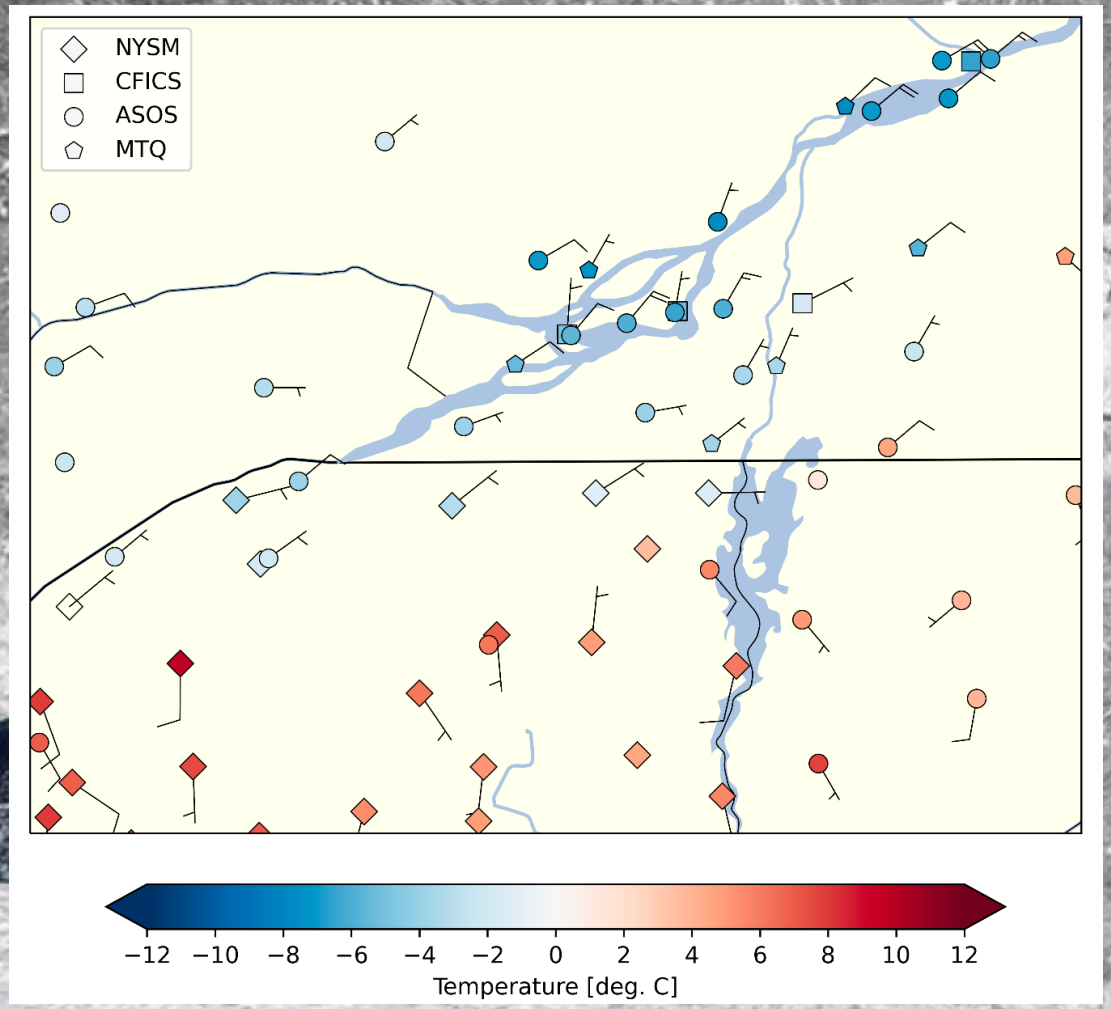
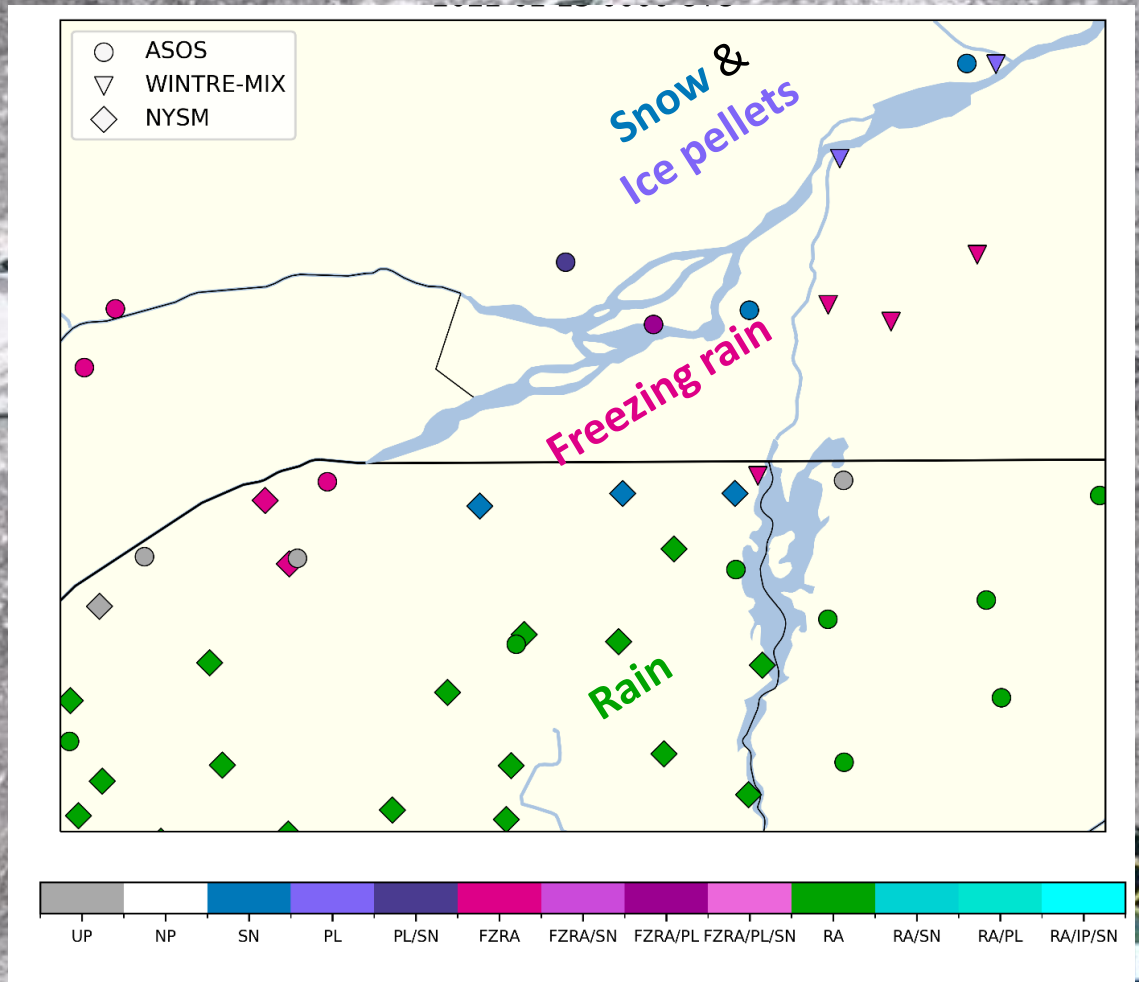
IOP5: *Mesoscale overview*

0000 UTC 23 February 2022

2-m Temperature
10-m winds (full barb = 5m/s)



Observed/diagnosed p-type



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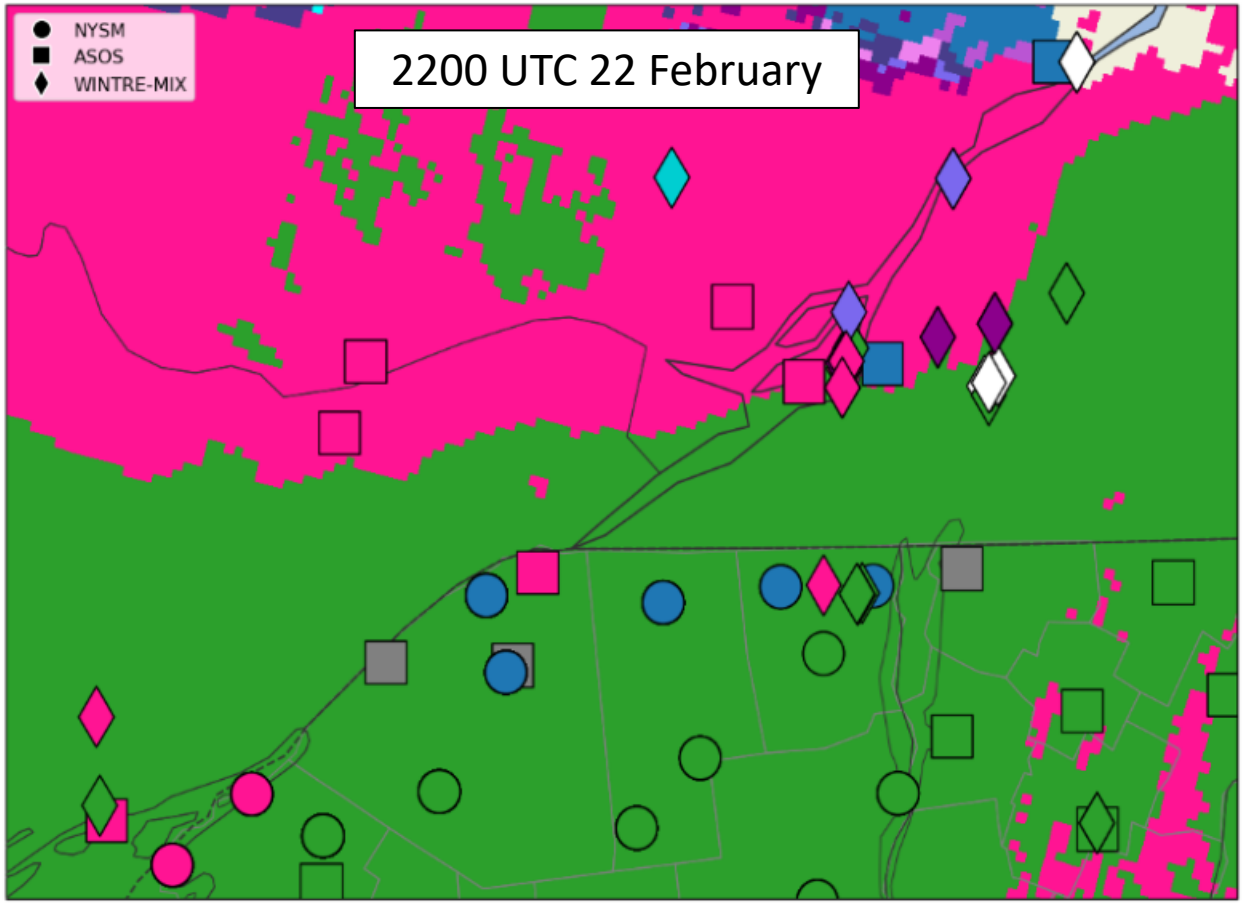
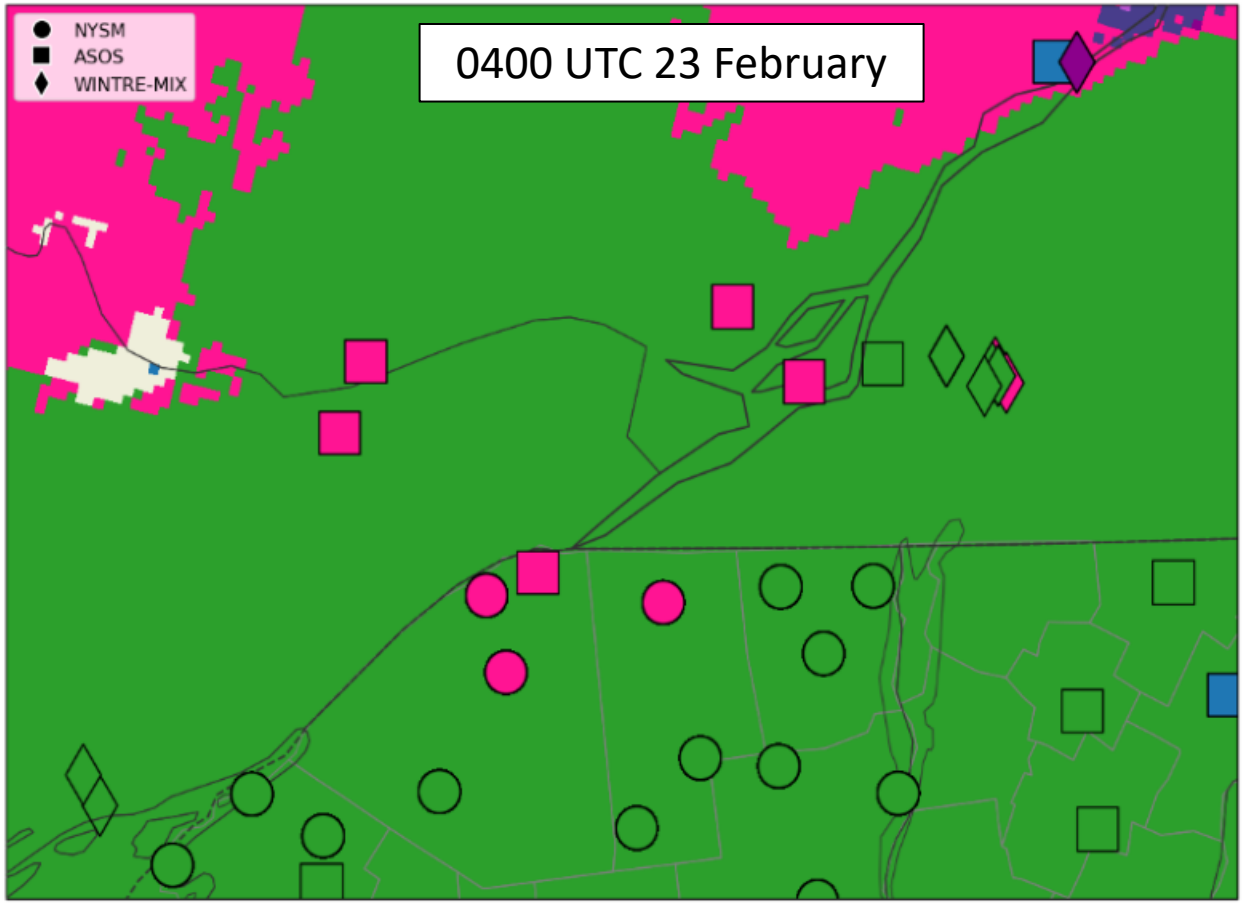
IOP5: *HRRRE dominant p-type vs. observations*





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Too much rain, too little freezing precip

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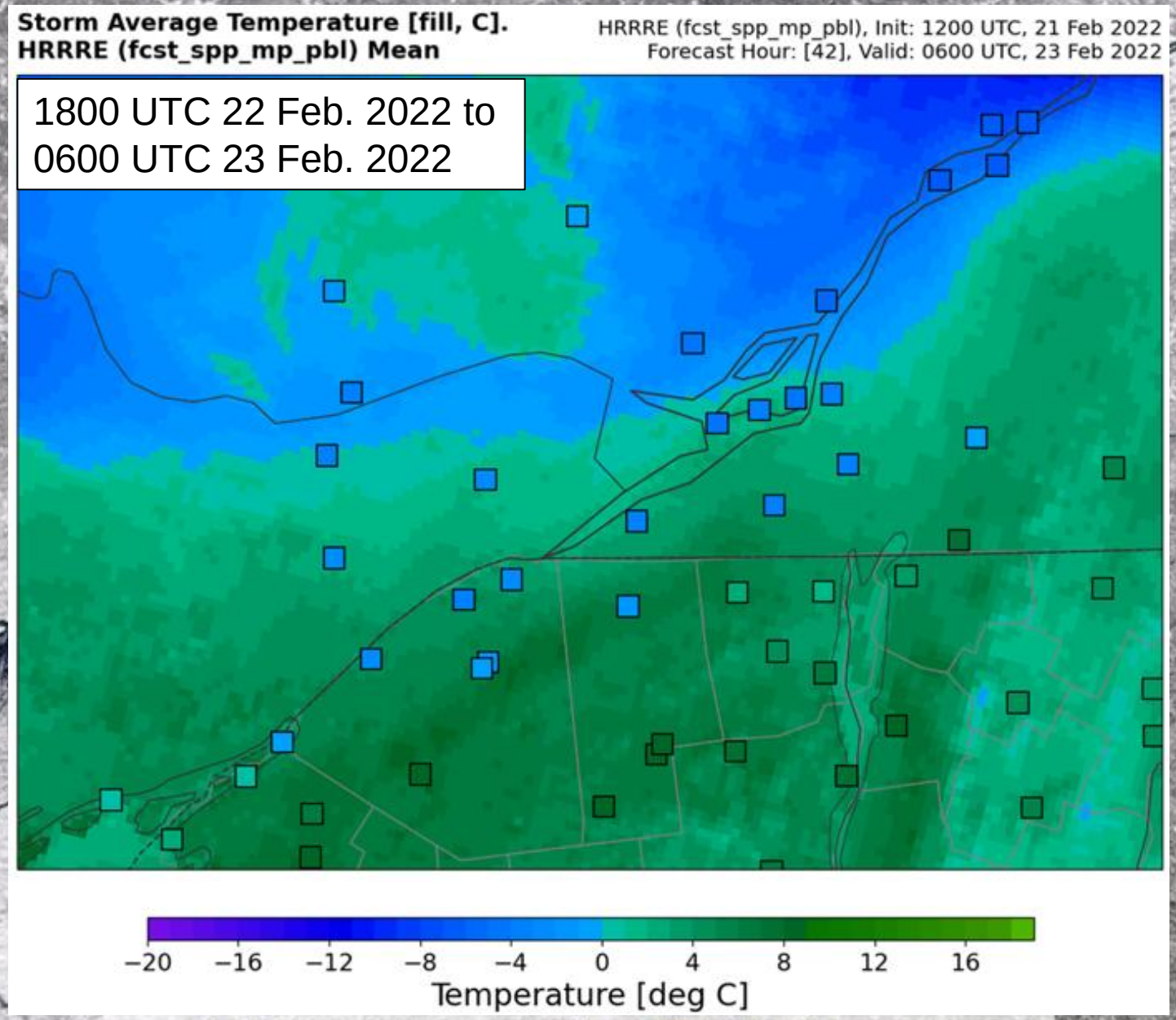
IOP5: *HRRRE ensemble-mean event-average temperature vs. observations*



Ensemble-mean is warm biased

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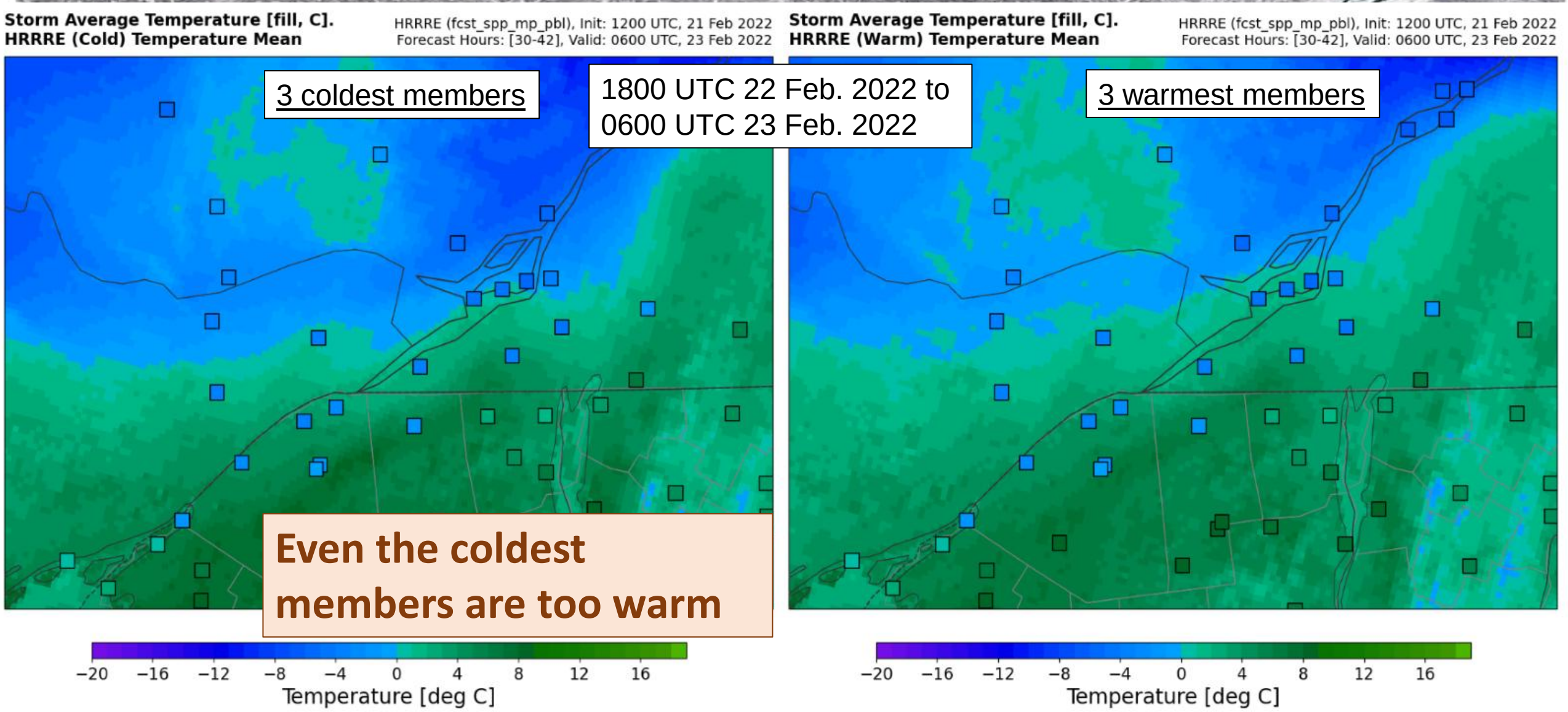
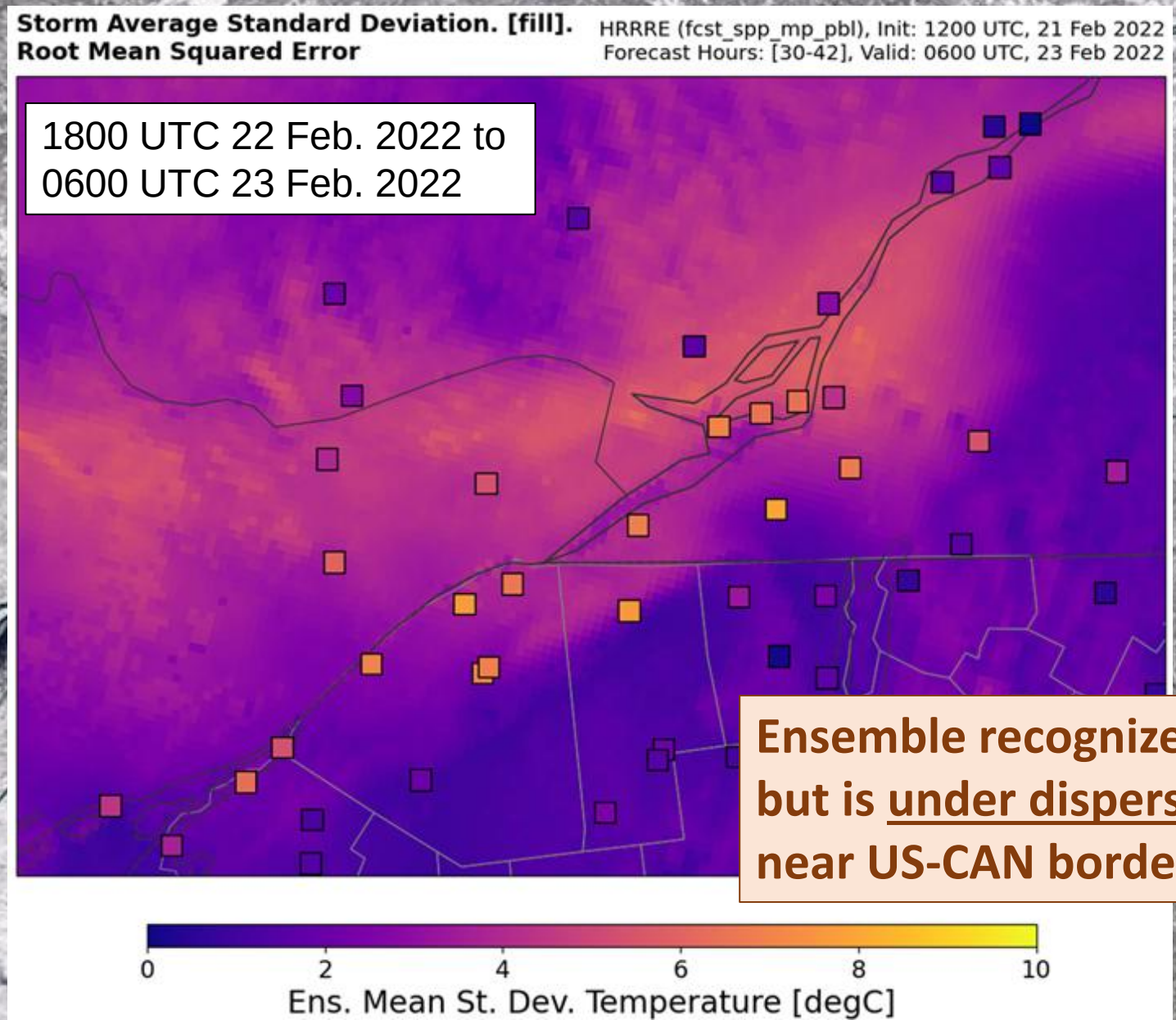
IOP5: *HRRRE warm vs. cold member event-average temperature vs. observations*



IOP5: *HRRRE event-average temperature spread and error*

- **Shading:** standard deviation across ensemble members (higher values suggest less confidence)
- **Makers:** root mean square error of ensemble forecast relative to observations (higher values = worse forecast)



Ensemble recognizes uncertainty, but is under dispersive especially near US-CAN border

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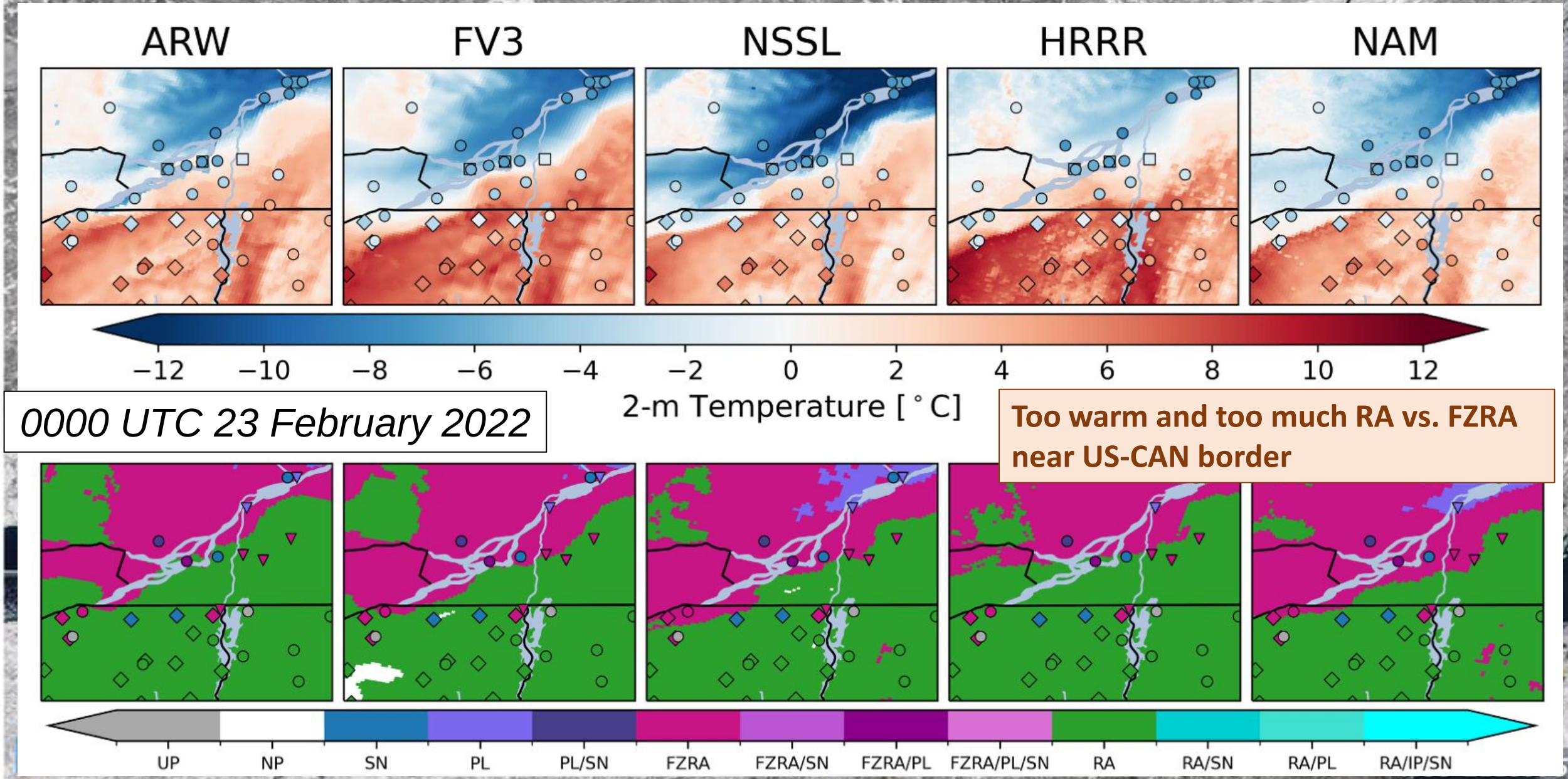
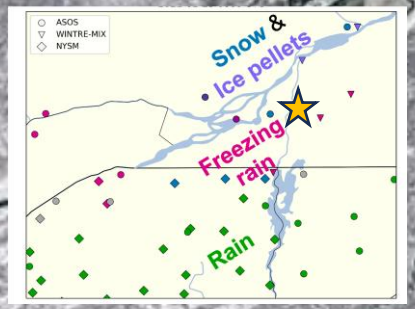
IOP5: *HREF temperature & p-type vs. observations*

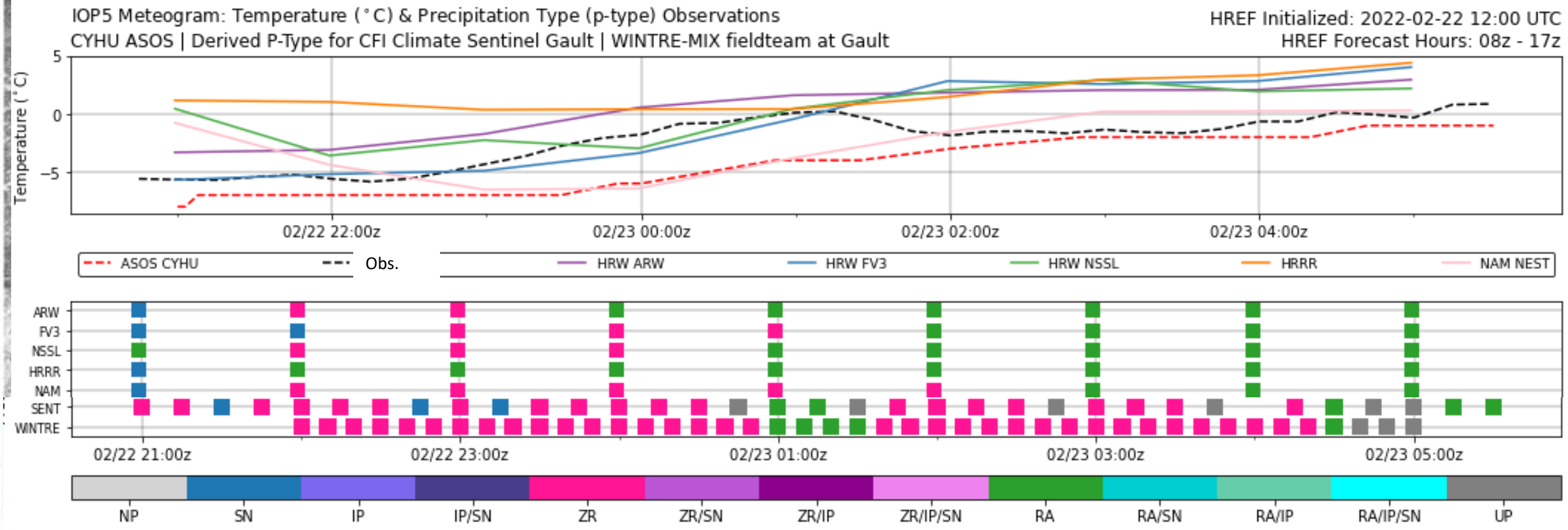


0000 UTC 23 February 2022

Too warm and too much RA vs. FZRA near US-CAN border

IOP5: *HREF temperature & p-type vs. observations @ Gault, QC*





Forecasts of rain instead of FZ rain due to temperature biases

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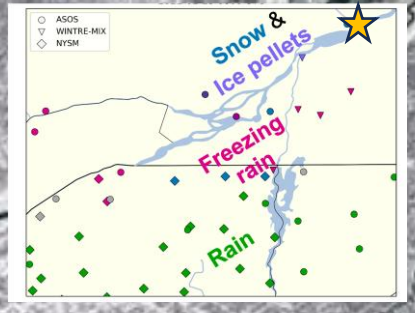
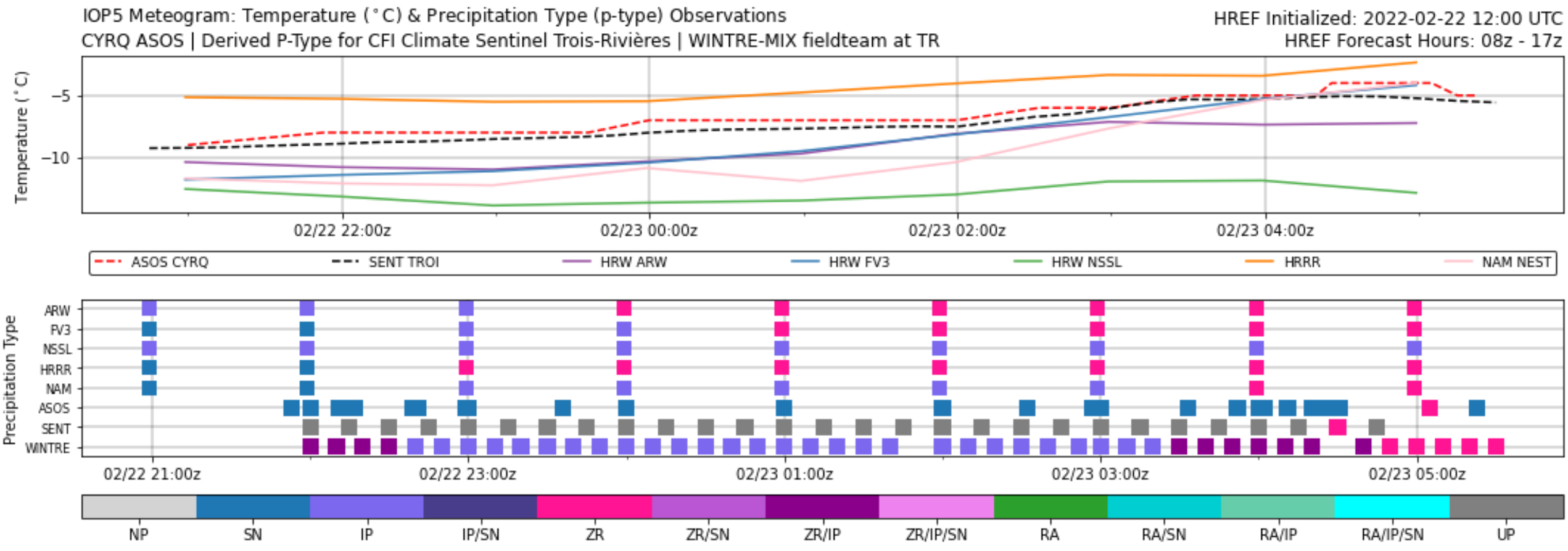
IOP5: *HREF temperature & p-type vs. observations @ Trois Rivieres, QC*





Ensemble members struggle with forecasting FZ rain vs. ice pellets

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Summary

- **WINTRE-MIX observations provide a rich resource for detailed evaluation of forecast models**
- **For IOP5, high-resolution ensembles (HREF, HRRRE) captured important mesoscale features influencing p-type but struggled with:**
  - Maintaining shallow low-level cold air in the St. Lawrence Valley
  - Producing sufficient spread in temperature
  - Predicting freezing rain to ice pellet transition

Next steps

- Compare models with other WINTRE-MIX datasets
- Examine other WINTRE-MIX cases
- Use long-term observational datasets to see how ensemble biases generalize over many storms
- Use controlled model experiments to isolate sources of bias and test improvements

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Extra slides

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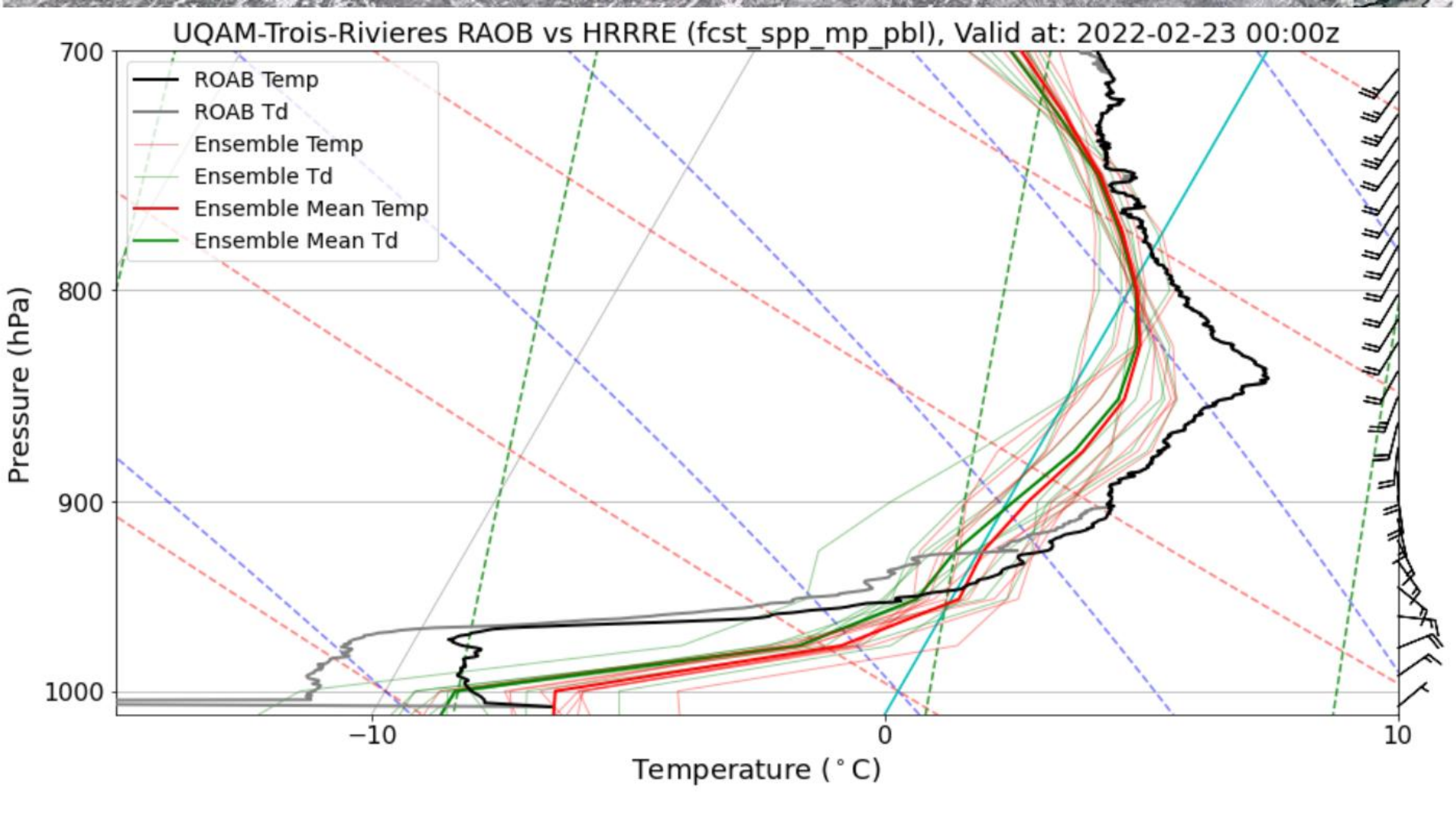
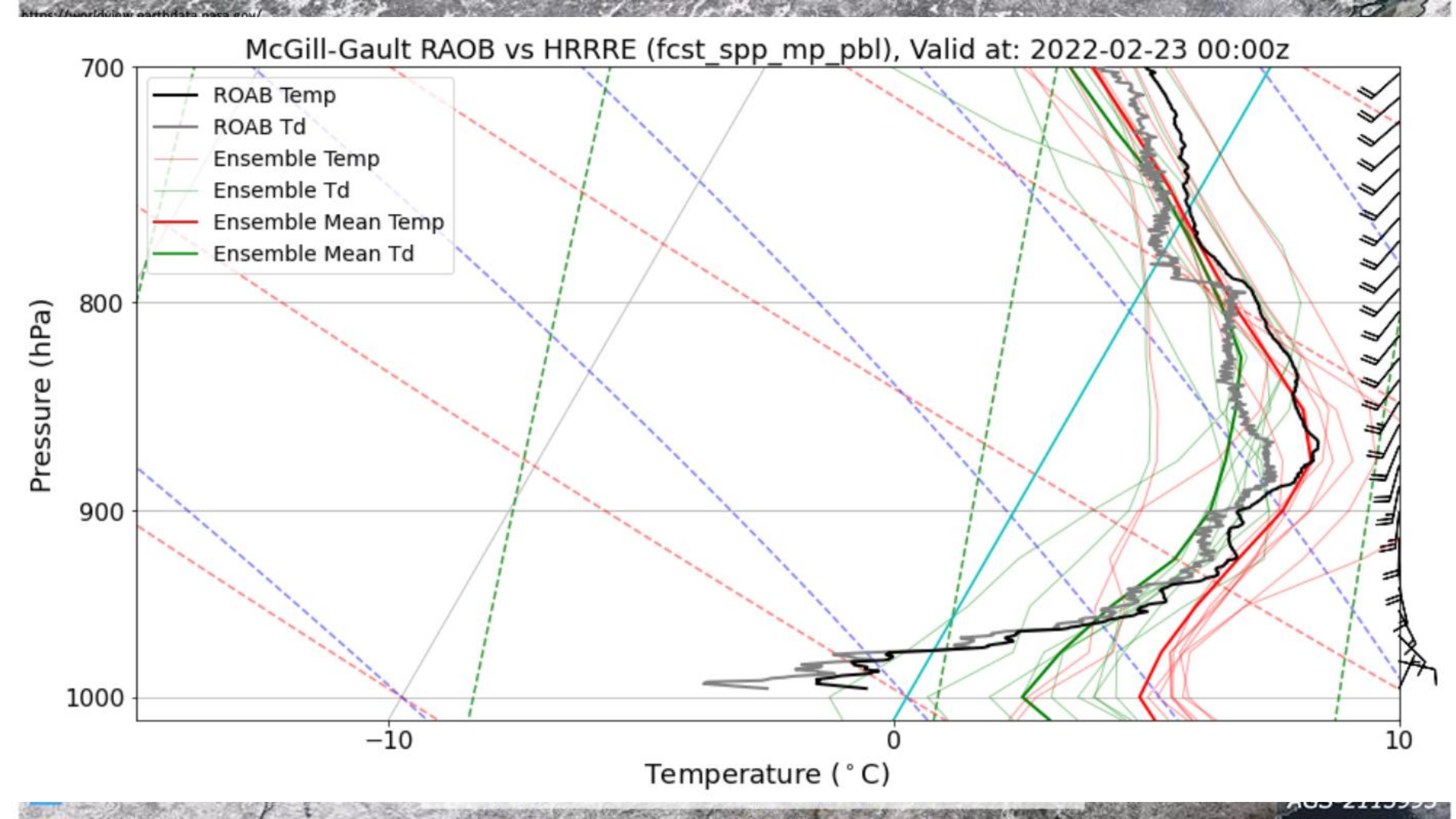
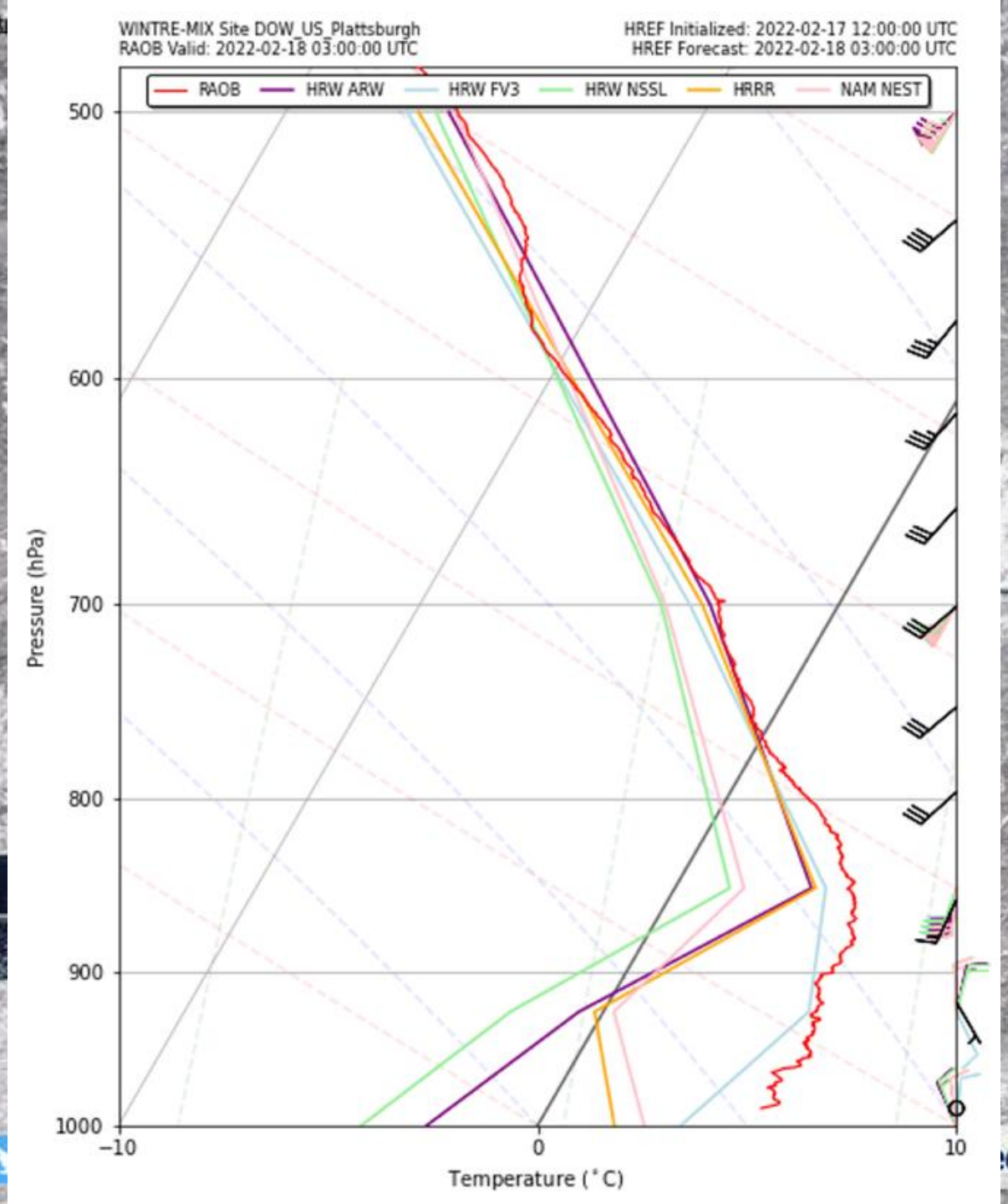
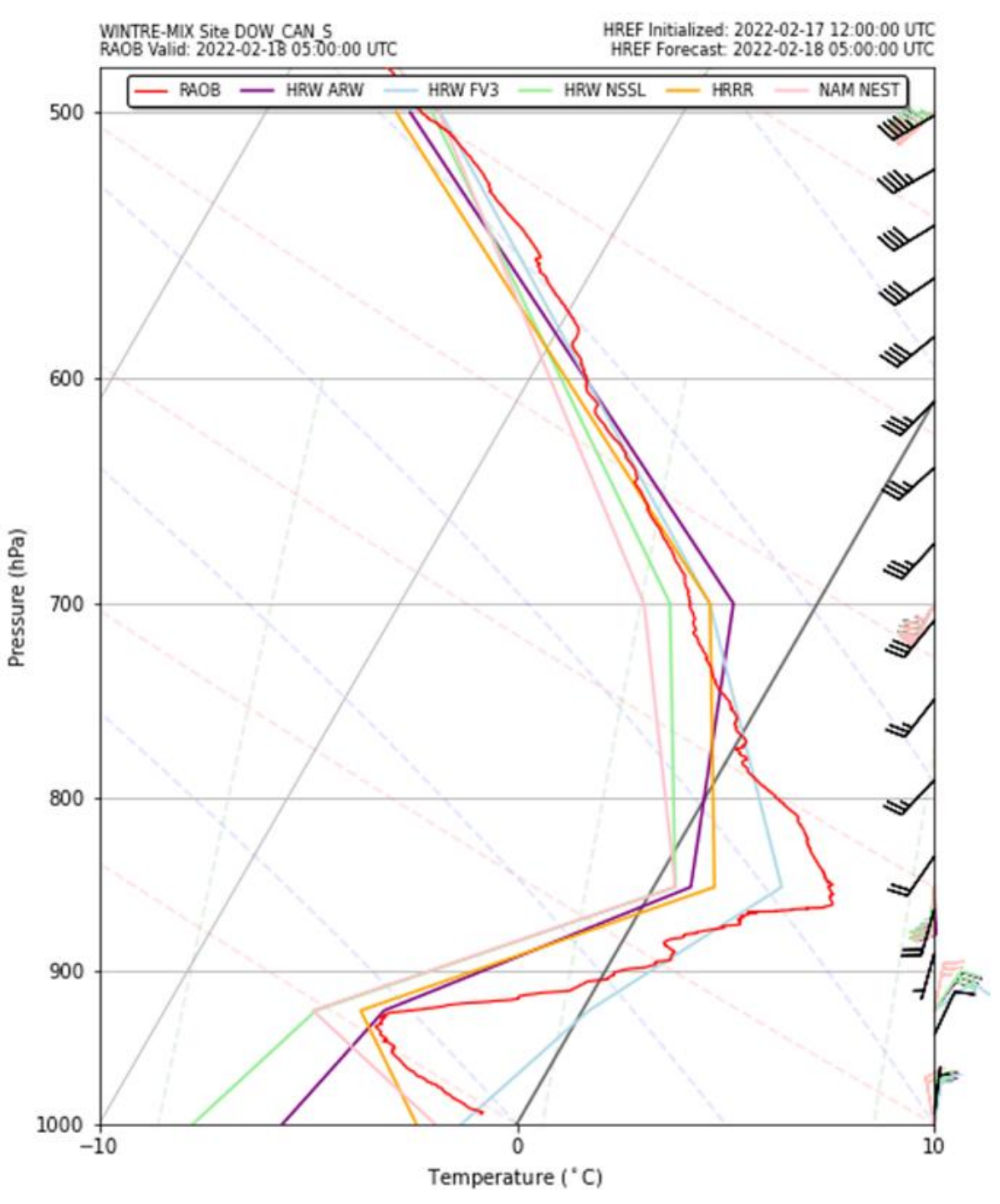

UQAM-Trois-Rivieres RAOB vs HRRRE (fcst_spp_mp_pbl), Valid at: 2022-02-23 00:00z
ROAB Temp
ROAB Td
Ensemble Temp
Ensemble Td
Ensemble Mean Temp
Ensemble Mean Td
Pressure (hPa)
700
800
900
1000
−10
0
10
Temperature (°C)


McGill-Gault RAOB vs HRRRE (fcst_spp_mp_pbl), Valid at: 2022-02-23 00:00z
ROAB Temp
ROAB Td
Ensemble Temp
Ensemble Td
Ensemble Mean Temp
Ensemble Mean Td
Pressure (hPa)
700
800
900
1000
−10
0
10
Temperature (°C)


WINTRE-MIX Site DOW_US_Plattsburgh
RAOB Valid: 2022-02-18 03:00:00 UTC
HREF Initialized: 2022-02-17 12:00:00 UTC
HREF Forecast: 2022-02-18 03:00:00 UTC
RAOB
HRW ARW
HRW FV3
HRW NSSL
HRRR
NAM NEST
Pressure (hPa)
500
600
700
800
900
1000
−10
0
10
Temperature (˚C)


WINTRE-MIX Site DOW_CAN_S
RAOB Valid: 2022-02-18 05:00:00 UTC
HREF Initialized: 2022-02-17 12:00:00 UTC
HREF Forecast: 2022-02-18 05:00:00 UTC
RAOB
HRW ARW
HRW FV3
HRW NSSL
HRRR
NAM NEST
Pressure (hPa)
500
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−10
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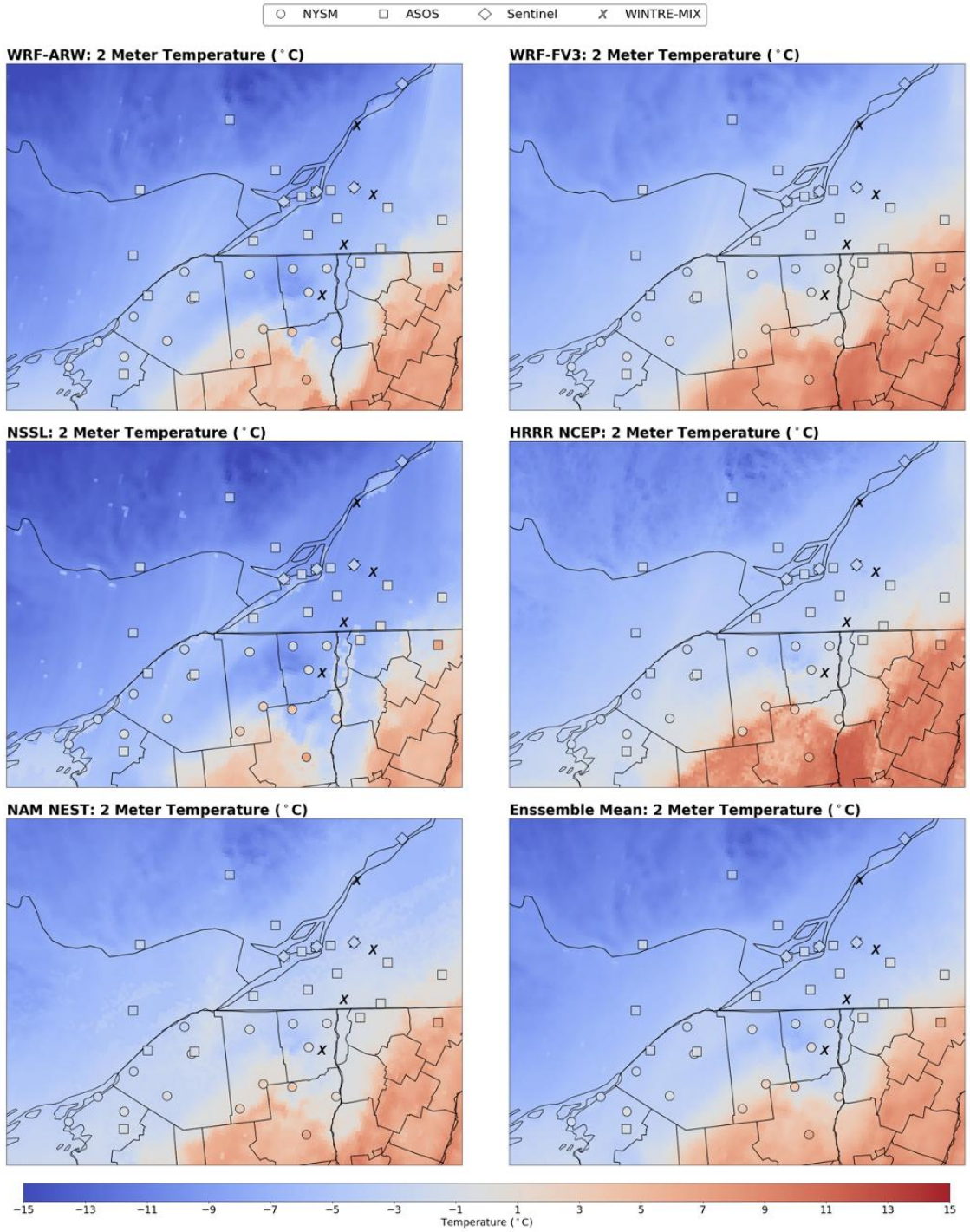
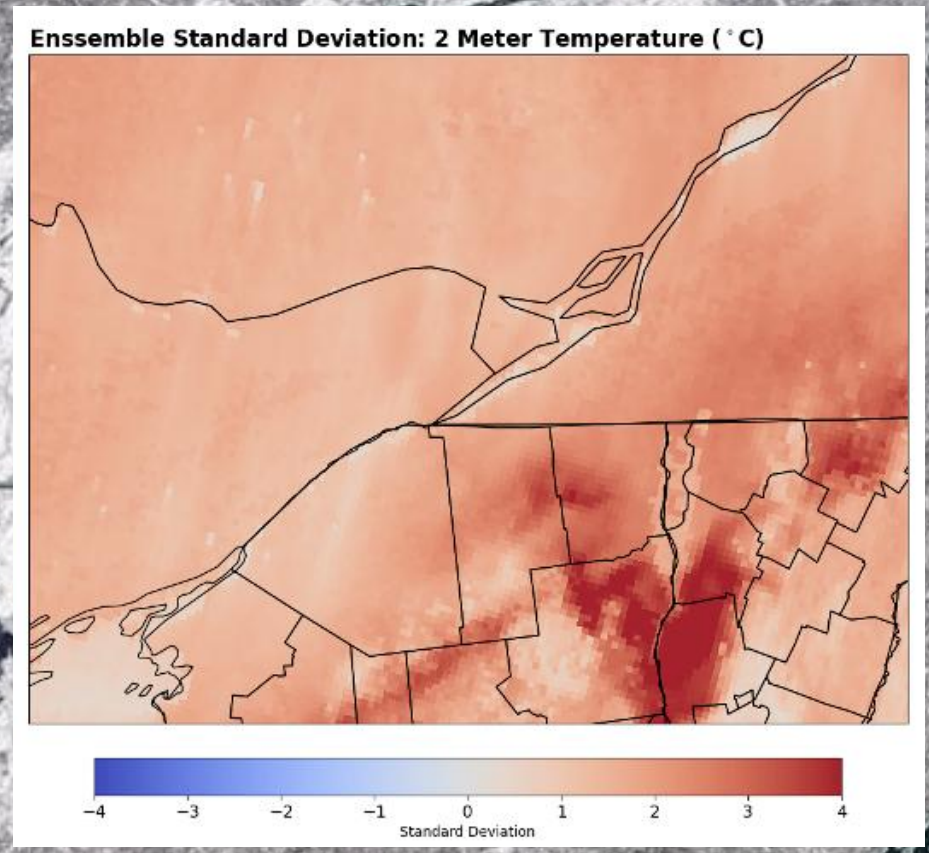
10
Temperature (˚C)





Initialized: 02/17/2022 at 12:00Z. Forecast Valid: 02/18/2022 at 03:00Z.

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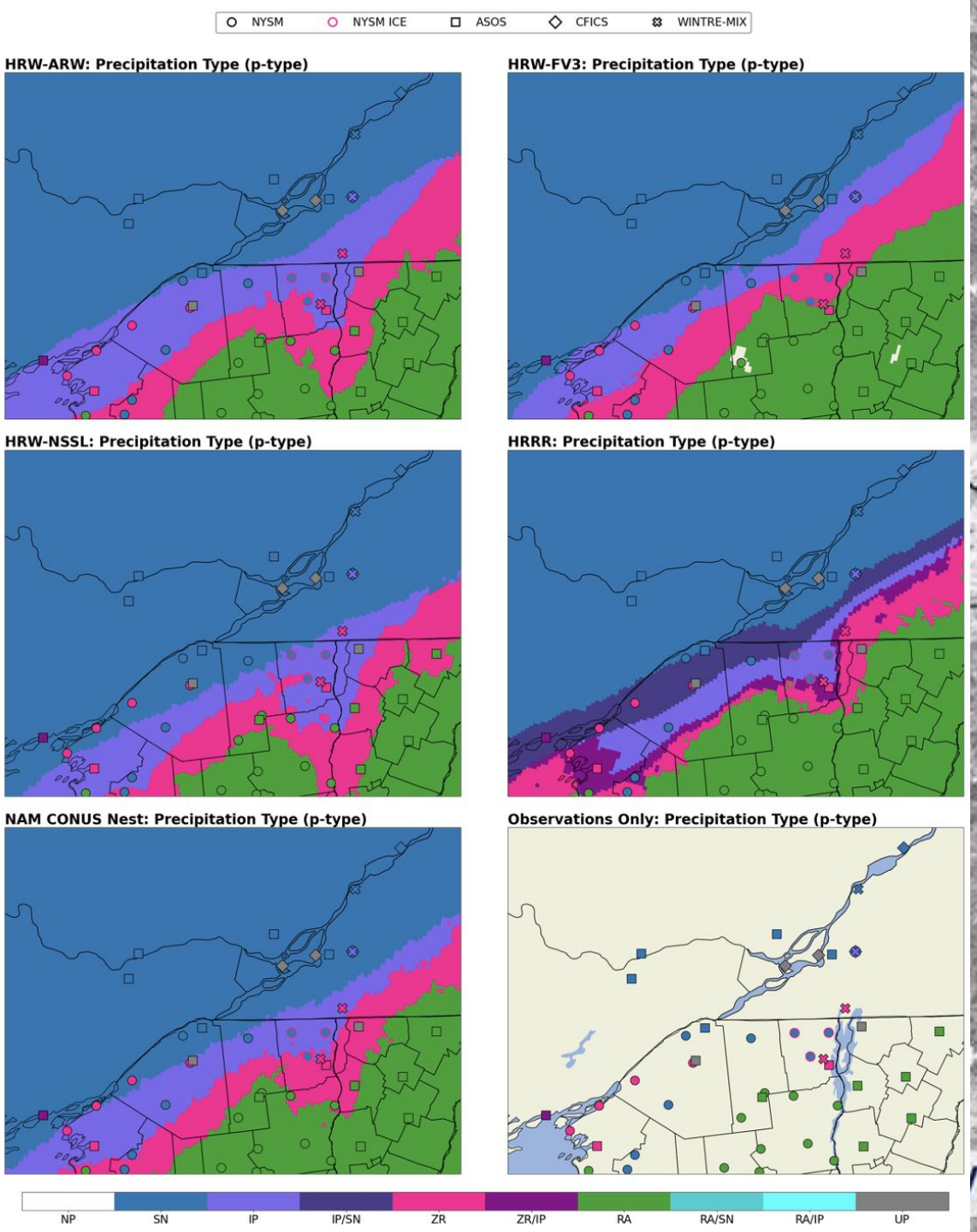

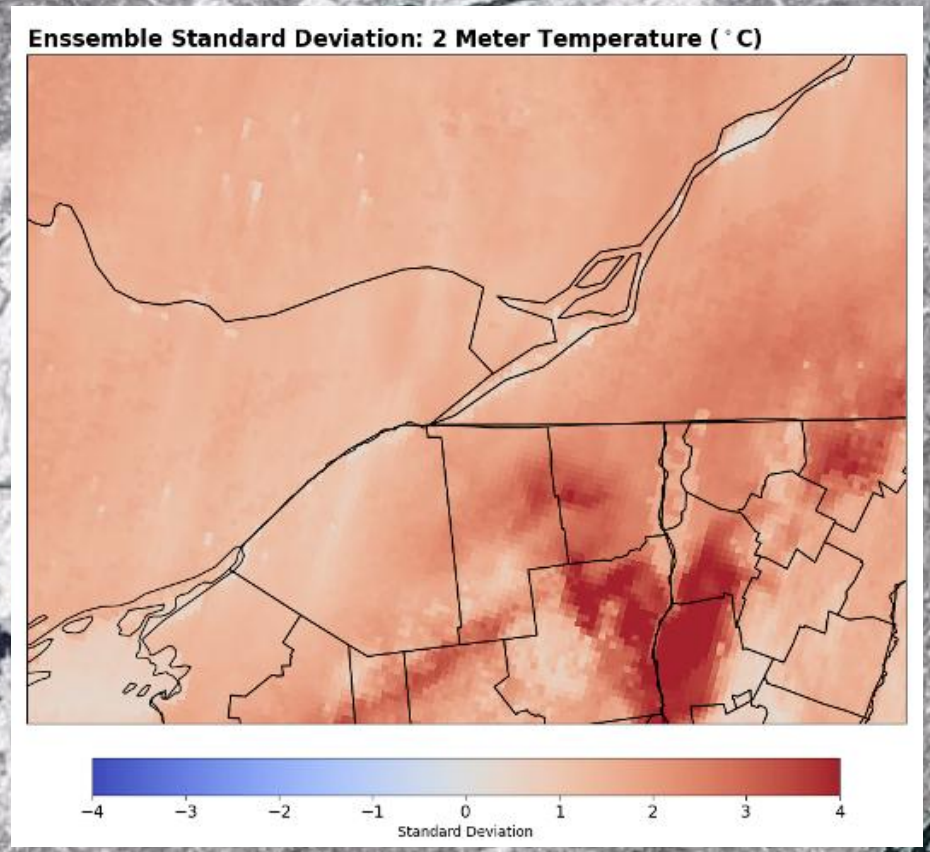

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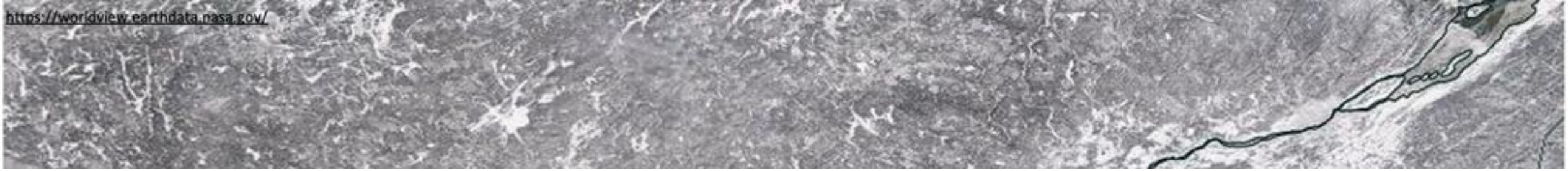
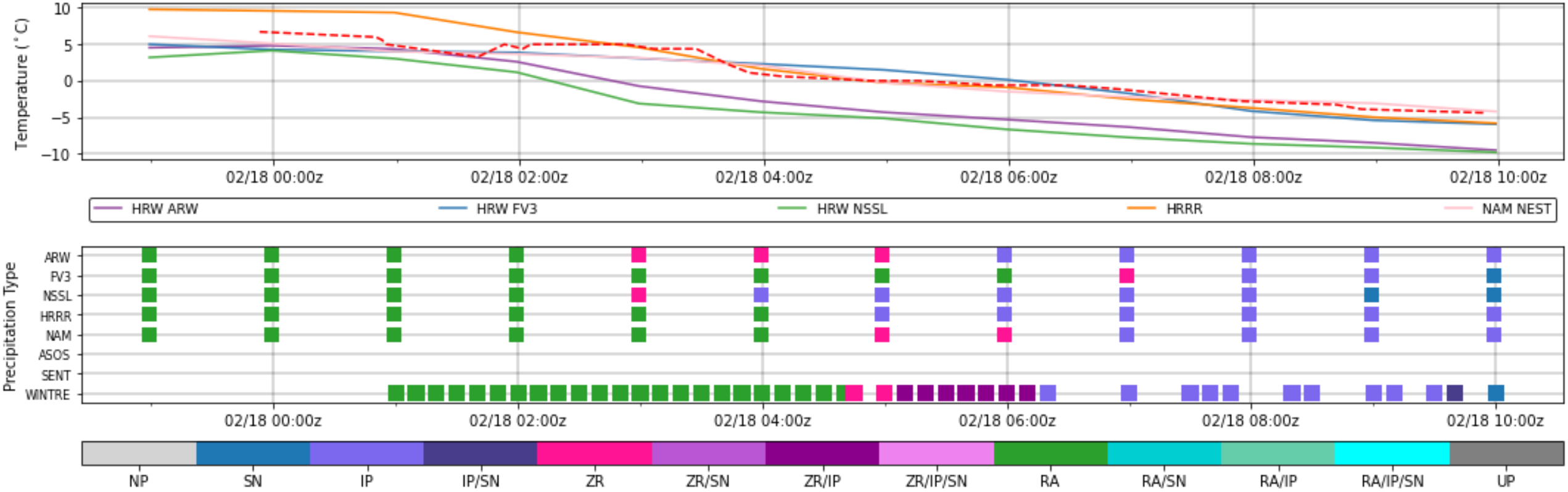


IOP4 Meteogram: Temperature (°C) & Precipitation Type (p-type) Observations
PBG ASOS | WINTRE-MIX fieldteam at DOW-US-Plattsburgh

HREF Initialized: 2022-02-17 12:00 UTC
HREF Forecast Hours: 10z - 22z



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